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Vol. X—No. 4

APRIL
1945

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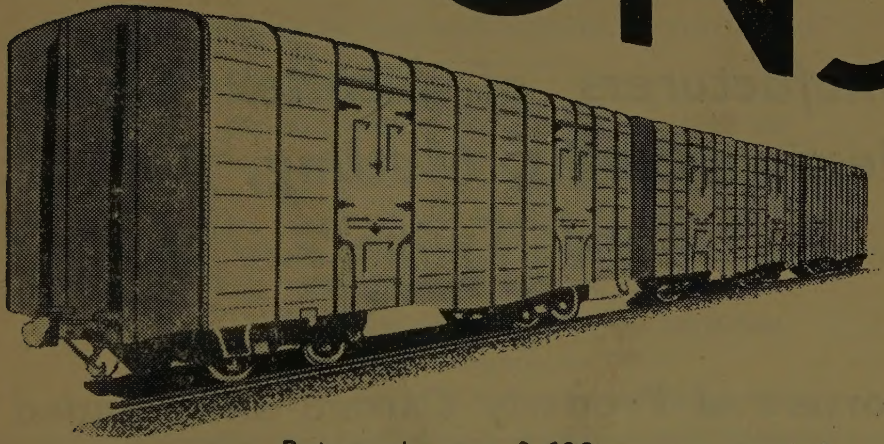

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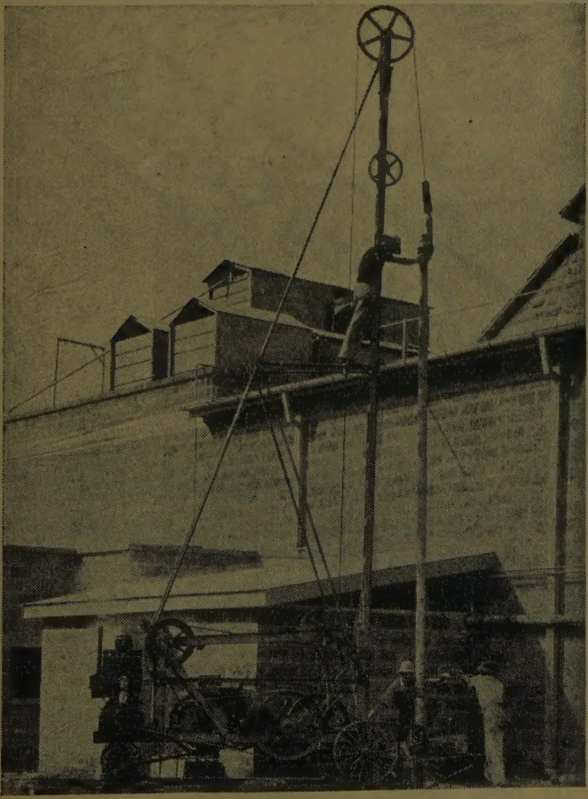

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Issued under the Authority of the East African Governors' Conference and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue).

UGANDA PHOSPHATE

A paper on Uganda phosphate by Gethin Jones which appears in this issue (page 195) will arouse considerable interest in the use of inorganic fertilizers in East Africa, and the result of this industrial development may have far-reaching effects on the agricultural methods, not only of European farmers, but also of native agriculturists. In its natural form, Uganda phosphate is insoluble in water but slightly soluble in dilute citric acid, the amount which dissolves in 1 per cent citric acid being a measure of its "availability" to the growing plant. In its availability, Uganda rock phosphate is not as good as other forms of rock phosphate, being only half as soluble in citric acid. However, by calcining the ground rock with soda ash from Lake Magadi, Gethin Jones has found that its availability to the plant is greatly increased, and thus it becomes a quick-acting fertilizer, as compared with the slow-acting natural rock, which must have time to weather before the phosphate can be taken up by the plant.

Rock phosphate is usually converted into superphosphate for use as a fertilizer, in order to raise its solubility in water, but it will be seen in Gethin Jones's paper that calcined Uganda phosphate is still insoluble in water, although it is nearly all soluble in citric acid. At first sight this seems a point in which the Uganda product is inferior to superphosphate, but in fact it is a very great advantage when other factors are taken into consideration.

The use of superphosphate has the disadvantage that, while the water-soluble portion is readily available to the plant, it also reacts quickly with iron and aluminium compounds in the soil, forming phosphates of iron and aluminium, which are insoluble both in water and in citric acid, and are so stable that they do not weather readily, if at all. Consequently, phosphate which has been "fixed" by the soil does not become available to the plant and it is wasted so far as the farmer is concerned. As an example of the extent to which phosphate fixation may take place in the tropics, one heavy clay soil showed, in laboratory tests, the power of fixing 18 cwt. of superphosphate per acre to a depth of 9 inches, all of which was rendered unavailable to the plant. The relationship between the three commonest forms of calcium phosphate will serve as an explanation of the difference between phosphatic fertilizers. Tricalcium phosphate, the chief component of rock phosphate and of bone meal, is insoluble in water and only slightly soluble in citric acid and therefore is not available to plants, but it gradually weathers to a more soluble form. Consequently, rock phosphate and bone meal are slow-acting fertilizers, but they have the advantage in some soils that their slow solubility gives the plant roots a chance of competing for them with the iron and aluminium compounds in the soil. Monocalcium phosphate, which is present in superphosphate, is soluble in water and in citric acid, and is thus readily available to plants, but it is easily washed out of well-drained soils, and it is rendered insoluble and almost unweatherable when it is fixed by the iron and aluminium compounds of some soils. Dicalcium phosphate has properties which are intermediate, in that it is insoluble in water but soluble in citric acid, so that the soil cannot fix it easily, and it is not readily washed away in the drainage water, but plant roots can dissolve it and use it as required. The calcined Uganda phosphate, being insoluble in water but nearly all soluble in weak citric acid, has the same solubility properties as dicalcium phosphate, and under tropical soil conditions it should be superior to superphosphate in effect.

In tropical soils, deficiency of available phosphate is so widespread that it is almost exceptional to find mature soils which do not show it, but lack of response to phosphatic fertilizers is also common, and even depressions in yield have been found in field experiments with phosphates. On the other hand, striking benefits obtained in Northern Nigeria with small dressings of farmyard manure were attributed very largely to the phosphate which the organic manure supplied, and similar increases in yield were obtained from equivalent dressings of superphosphate, though not of rock phosphate. The reactions of phosphate in soil are not fully understood, and lack of response to Uganda phosphate should not be taken as proof either that the soil does not need it or that this form of phosphate is not suitable. Applications of lime sometimes reduce the fixing power of the soil, and other factors may come into play in individual cases. The calcined Uganda phosphate seems, theoretically, to be the best form of phosphate to use in East Africa, because it is not likely to be fixed by the soil, but this does not mean that it will show a profitable response on every field. Field experiments and laboratory studies of the mechanism of phosphate fixation in East African soils are required in order to find how and where to use the fertilizer. The method of application may be important, since it has been found with cereals in England that by using a double seed box, which delivers both seed and fertilizer in the same row, a great saving is obtained, even to the extent that the phosphate is three times as effective as in broadcasting. Thus it is not merely a matter of spreading phosphate over the land and reaping a rich harvest.

While it is intended to strike a note of caution in these remarks, they should not be interpreted as the warning of a pessimist. There is every justification for optimism in the fact that large supplies of local phosphate will shortly be available, in the chemical form, which is most likely to be successful. Yet every field must be an experimental plot, and where the response is not up to expectation, we must find out why. We are obviously entering a new era in agricultural production, in which the soil is to be given its "production ration" in the same way as a high-yielding milch cow is carefully fed in order that it may give its maximum yield. Increased yields due to the application of phosphorus may bring out deficiencies of other elements, and eventually the soil, like the pedigree cow, will have to get its "balanced ration". When that is achieved, the result should be much more efficient production.

D.W.D.

REVIEW

A MONOGRAPHIC STUDY OF BEAN DISEASES AND METHODS FOR THEIR CONTROL, by L. L. Harter and W. J. Zaumeyer: U.S.D.A. Tech. Bull. No. 868, June, 1944, Washington, D.C. Price 25 cents.

This comprehensive monograph comprises 160 pages. With few exceptions all the known fungus, bacterial and virus diseases of French and Lima beans are mentioned. In addition a few diseases caused by eelworms and insects and a number of non-parasitic troubles are dealt with. Various diseases which occur in transit and in marketed crops receive attention.

Symptoms and methods of control are adequately described for all the more important troubles. There are many excellent illustrations and 571 references to literature on the subject are cited.

Having as a guide the lists of bean diseases recorded from East Africa and published in this Journal, the bean grower should have little difficulty in recognizing the diseases he is likely to encounter in his fields. Caution is necessary however and confirmation by the local Departments of Agriculture is always advisable.

This is a publication which should be in the hands of bean growers, particularly those growing the crop for seed.

It might be noted that the fungus named *Macrophomina phaseoli* is sometimes listed in East Africa as *Rhizoctonia bataticola*. Seed coat splitting ("Burst skins" of Tanganyika) is considered to be heritable. Among crops suggested for rotation with beans on land infected by Sclerotinia are potatoes, but that crop is susceptible to the disease here and would be unsafe.

G.B.W.

EAST AFRICAN SUPPLIES OF PHOSPHATES AND THEIR UTILIZATION

By G. H. Gethin Jones, M.Sc., Soil Chemist, Department of Agriculture, Kenya, on behalf of the Panel on Heavy Chemicals (Phosphatic Fertilizers), East African Industrial Research Board

(*Received for publication on* 19*th December*, 1944)

It is now recognized that the basis of the maintenance of soil fertility in East Africa must depend very largely on the utilization of suitable temporary grass leys and phosphatic manuring. In established farming countries, more especially where there are leached acid soils, phosphatic manuring has long been found essential for good crop yields and nutritious pastures. From now on, the economy of more intensive farming in East Africa, especially in the more elevated, higher rainfall, areas, must depend a great deal upon adequate and suitable supplies of cheap phosphatic fertilizers. It is estimated that there are about five million acres of cultivated soils in East Africa that would benefit to varying degrees from phosphatic manuring and that, with the development of better farming methods in the native reserves, there will be need for something like 50,000 tons of phosphatic fertilizers per annum.

Early work on the soil-phosphate status of local soils was carried out mainly with the red lateritic coffee soils of Kenya and the use of such materials as bonemeal and Seychelles phosphate has long been an established practice on coffee estates. On the main arable soils, only a limited amount of investigational work had been carried out before the war but it had shown that many of the main soil types, such as those used extensively for the growing of cereals, were in great need of phosphatic manuring. Many farmers who did apply phosphates with the seed drill often obtained very marked responses. With the extension of cultivation on to less fertile soils, the efforts made to increase yields per acre under war-time conditions, and also the granting of a subsidy on phosphatic fertilizers by the Government of Kenya and a certain amount of propaganda work, the practice of applying phosphates to cereals has now become widespread. It is likely that the main factor that has brought about a tenfold increase in the use of phosphatic fertilizers with cereals since the beginning of the war was the very good response usually obtained in the field. Owing to the very great increase in demand, which now amounts to about 7,000 tons per annum, coupled with the scarcity of supplies, largely due to the difficulties of importation, phosphatic fertilizers have had to be rationed. Efforts were made to develop local supplies to make good the shortage. Many thousands of tons of cotton seed ash were obtained from Uganda and arrangements were made for the extension of the collection and milling of bones, but bulk supplies still had to come from overseas, partly as Seychelles phosphate but mainly as superphosphate or triple superphosphate imported from North America.

In the meantime, much attention had been given to the possibilities of using certain phosphate-rich rocks which were known to occur to the south-west of Mount Elgon in Uganda. Laboratory and field work has been done to determine the true manurial value of these deposits when used as finely ground raw mineral phosphates, and also on the possibilities of processing the rocks with locally occurring reagents so as to improve their availability to crops.

Finely ground Uganda rock-phosphate

The major part of the phosphate portion of the Uganda rock-phosphate is present in the form of the minerals fluorapatite and phosphorite mixed with magnetite, phlogopite mica and other minerals. The usual more readily available mineral rock-phosphates of commerce are those which contain most of their phosphate in the form of tricalcium phosphate or phosphorite. When the phosphate is in combination with fluorine as in the more stable fluorapatite mineral, it is less available to plants. The Uganda source of a deeply weathered, metasomatic rock contains a mixture of both forms. This material would be expected to be intermediate in availability between that of the North Africa or Seychelles type of mineral phosphate and the mainly apatite form. Apart from floaters of hard rock, the weathered material can easily be worked and usually there is only a little over-burden. The weighted mean phosphate-content of the material taken from the quarry face amounts to the equivalent of about 25 per cent phosphoric oxide. It was necessary to assess the true value of this material when used as a finely ground mineral phosphate. This has been done by three methods. Chemical tests were used to note how much phosphate, in comparison with other known phosphatic materials became soluble or "available". Secondly, pot-culture methods were employed whereby the roots of rye and wheat seedlings were used to extract the phosphate nutrient from different soils to which this Uganda rock-phosphate and other phosphatic fertilizers had been added and, thirdly, co-operative field experiments were laid down in different districts.

The proportion of "citric-soluble" phosphate in such Uganda rock-phosphate amounts to about 15 to 20 per cent as compared with 30 to 40 per cent for other forms of rock-phosphate used. Again, the amounts extracted by the roots of seedlings during two weeks' growth—according to soils used—amounted to 4 per cent to 7 per cent of the total phosphate content as compared with about 10 per cent for other mineral phosphates. The phosphate recovery with seedlings was found to be closely related to the availability of the phosphate as shown by the citric-solubility test. The third method of assaying the real manurial value of ground, raw, Uganda rock-phosphate has been by field experimentation. In some of the field trials, even when proved commercial types of phosphatic fertilizers were included, the results were masked by the layout of the co-operative trials being too simple, as compared with the local variations in the soil fertility. In one trial on a phosphate-deficient soil, where the response to all forms of phosphates was shown to be highly significant, finely ground Uganda rock-phosphate applied at 160 to 260 lb. per acre with the seed drill gave 6½ to 7½ bags of rye per acre compared with 8½ bags per acre of land given 200 lb. of Seychelles guano and compared with only 4½ bags of rye per acre of land receiving neither manure. Thus the three methods of assay have shown that Uganda rock-phosphate, when ground so that 90 per cent passes through a 60 I.M.M. screen, is suitable for use, though a greater amount has to be applied so as to allow for its lower relative availability. In general it will not be advisable to apply Uganda rock-phosphate by itself to annual crops. It will be necessary to add a proportion of a more rapidly available phosphate to a mixture so as to ensure ample supplies of this nutrient during the first few weeks of growth. The mixtures recommended for cereals will probably be one, two or three parts of Uganda rock-phosphate mixed with one part of superphosphate or the new, locally prepared, readily available, phosphate that will be referred to later in these notes when this is put on the market. The proportions used will vary with the soil and with the crop grown. It will be necessary to replace one part of Seychelles phosphate as used at present by about 1½ parts of the finely ground Uganda rock-phosphate. Further field experiments were laid down in 1944 and the results will be made known in due course. One feature of using a heavier dressing of the less early-available, but much cheaper local rock-phosphate will result in a greater accumulation of residual phosphates that go to build up soil reserves of this nutrient such that smaller dressings need be given in future. This form of phosphatic fertilizer can be used to greater advantage with permanent crops and, more especially, grasslands than with annual crops.

The preparation of a highly "citric-soluble" phosphatic fertilizer from Uganda rock-phosphate

As indicated above, there is need for cheap supplies of a more readily available phosphate for compounding fertilizer mixtures to meet the special requirements of annual crops, such as cereals. Such a material would, in the main, replace imported expensive superphosphate and triple superphosphate in a fertilizer mixture. The possibilities were the local manufacture of either a "water-soluble" superphosphate type of fertilizer by treatment with sulphuric acid or a highly "citric-soluble" material prepared by heating Uganda phosphate with silica (diatomite), the carbonates of the alkalis or alkali earths or a mixture of these. The high iron-content of the ore, due to the presence of large amounts of the mineral magnetite, made it unsuitable for the sulphuric-acid treatment. In any case, even if the ore had a sufficiently low content of iron compounds, it was considered that such "water-soluble" phosphates would be less suitable for large areas than a highly "citric-soluble" material. The most suitable choice, more especially as the treatment involves less high temperatures, was found to be a calcination of the ground rock-phosphate with sodium carbonate or Magadi ash. A simple laboratory process has been evolved, whereby the ground fluorapatite and phosphorite rock is mixed with Magadi ash and subjected to a thermal treatment. The original phosphate minerals are broken down with the liberation of a part of the fluorine and new sodium and calcium phosphate compounds with different chemical properties are formed. The synthetic fertilizer thus produced is found to have very little water-soluble phosphate but five or six times as much "citric-soluble" phosphate as the untreated ground rock-phosphate. The proportion of the total phosphate that is "citric-soluble" is raised from 15 per cent to 20 per cent in the raw ground rock to about 90 per cent in the new product.

It has been shown that the leached acid lateritic soils very readily tie up "water-soluble" phosphates such that these become much less available to plants and that non-water-soluble, but highly "citric-soluble" phosphates, such as the material which has now been produced in the laboratory, are better suited to such soil conditions. The new product thus meets the special requirements of many East African soils. The true manurial value of the "availability" of this new product has been tested out by chemical and pot-culture methods and field trials will be laid down in 1945 when sufficient quantities for this purpose will have been prepared. The "citric-solubility" of new fertilizer depends on the proportion of soda added and the time and temperature of calcination. It is likely that material with about 90 per cent of the total phosphate present in the "citric-soluble" form can be prepared at a fairly low cost such that it can be sold at a cheaper rate per unit value than imported materials of the superphosphate class. A good deal of pot-culture work has been carried out with this new product when it has been added to many of our local main soil-types. This work has shown that the intake of phosphate nutrient by rye seedlings during two weeks' growth amounted to 18 to 25 per cent of the total phosphate added as compared with 4 to 7 per cent in the case of the raw ground Uganda rock-phosphate; this is comparable with an intake of 13 to 23 per cent with superphosphate. When different grades of the prepared fertilizer were used, it was noted that the intake of phosphate by the seedlings was closely correlated with the "citric-solubility" of the materials as determined by laboratory tests. This pot-culture work has shown that the early availability of the new phosphatic fertilizer was about similar to that obtained with superphosphate . It was more available with certain acid lateritic soils and slightly less so with some other less reactive soil types. In the case of a longer period of growth than is possible with pot-culture trials, one would expect this highly "citric-soluble" but "water-insoluble" material to be rather better as it would be less likely to become reverted in the soil.

At present further work on the best commercial methods of processing is being done in a pilot plant, and, unless some unforeseen difficulties arise, it is hoped that unfailing cheap supplies of a very suitable phosphatic fertilizer containing the equivalent of about 25 per cent of "citric-soluble" phosphoric oxide will be prepared locally. The new fertilizer, balanced with varying amounts of finely ground Uganda rock-phosphate, will enable the farmer to compound suitable mixtures for different crops and soils. The mineral phosphate is now being milled and will be on the market from 1945 onwards and it is hoped that the new synthetic phosphatic fertilizer will follow in the early post-war years. It is good to know that East African requirements of phosphatic fertilizers for many centuries to come may be fully met from local sources of supply and manufacture.

Almost everyone in the modern world has occasion to write. And much—in everybody's life—depends on whether it is done well or badly. From a proposal of marriage to a local government direction on the disposal of scrap, clarity and persuasiveness can make all the difference between success or failure. Yet the principles of good writing are almost universally ignored. The business is treated as either something anyone can do without thought or trouble or, alternatively, as an inspired attribute of genius enjoyed (also without thought or trouble) by the chosen. And both propositions are utterly untrue.

These are only two elementary rules. One is to say what one has to say in the fewest and simplest possible words—that is in such language as in a busy world stands the best chance of being read. The other—and this serves the same end—is to say it in such a way as to hold the flagging attention of one's reader . . .

Prolixity and dullness are fatal, for they defeat the very object of writing. They prevent it from being read . . .

The finest test of all writing is to read it aloud. Human beings are partly governed by rhythm. It helps to carry them along.

ARTHUR BRYANT.

ELGON DIEBACK DISEASE OF COFFEE

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The disease known locally as Elgon dieback was prevalent in coffee estates on Mt. Elgon in 1934, when investigations of this disease were begun at Kapretwa Estate, near Kitale, in Kenya Colony. Later, it became evident that this disease was more widespread in the Colony than was indicated by the local name. A constant association was found between the occurrence of Elgon dieback and the presence of "hot and cold" symptoms in the coffee. "Hot and cold" is the name given to certain characteristics associated with the pyramid-shaped coffee trees with bunched growth-habit, typical of Arabica coffee at the higher elevations. The apical leaves of such trees are small, curled and often blackened. These appearances have given rise to the names "Curly-leaf" and "Black-tip" in Kenya [1] and "Brulure" in the Belgian Congo [2].

In its mildest form, Elgon dieback is little more than a severe case of the "black-tip" appearance associated with "hot and cold". It is typical of Elgon dieback for there to be a blackening at the base of the large leaves, as well as at the tip of the stem or branch, as in "hot and cold". At the other extreme, Elgon dieback resembles the death of branches resulting from overbearing or loss of leaf, with which most coffee growers are familiar. The distinctive difference is that in Elgon dieback there are a few leaves remaining, usually at the tip of the branch, when the disease is first observed. In ordinary dieback, the branch dies only when it is practically bare of leaves.

The descriptions of certain maladies of Arabica coffee occurring in other countries suggest that the disease now referred to as Elgon dieback has occurred elsewhere than in Kenya. Amongst forms of dieback which Small [3] observed in Uganda was one which he described as producing the appearance of a tree scorched by a bush-fire. This description would be equally apt in the case of severe incidences of Elgon dieback.

Less convincing, but none the less interesting, are certain coffee diseases recorded in India, which appear to have been similar to Elgon dieback. The occurrence of brown lesions on the internodes, associated with a considerable fall of leaf, has been reported in Mysore [4] where the development of dieback was stated to be extremely uneven, a feature which was noted in the closely similar, if not identical, Nilgeri twig disease [5] in 1904. In regard to this latter, it was noticed that new leaves were small, pale and crumpled, which agrees with the description of the condition known as "Curly-leaf", "Black-tip" or "Hot and cold" as given by Trench [6].

The writer has previously reported [7] on the fungi found in association with Elgon dieback. When the earliest stages of this disease were examined in the laboratory, no fungus or other parasitic organism was found in the affected shoots. In more advanced stages of the disease, stems were often found to be infected by two fungi in particular (*Phoma* sp. and *Colletotrichum coffeanum*). These fungi were used to inoculate healthy stems, but in no case was the disease produced by such means. It was concluded that such fungi were present as secondary organisms and were not primary parasites. The production and dispersal of such fungus spores from affected material could not therefore be expected to affect the incidence of the disease. Nevertheless, it was important for growers to know whether, as a control measure, they should remove the shoots affected with dieback. Accordingly, an experiment was undertaken to determine whether there was a difference between the number of dieback shoots produced on adjacent plots receiving either of two treatments, namely: (1) no removal of dieback from the trees, (2) removal of dieback shoots at frequent intervals. In the course of such observations made during a period of five years, it was found that there was no significant difference between the two treatments as regards numbers of dieback stems produced. It was concluded that the removal of dieback from the trees was not effective as a control measure. This experiment provided further support for the belief that Elgon dieback was not due to parasitic attack, but that it was probably a physiological disease, as suggested previously [7]. The significance of shade in this connexion has already been observed [7], and at the same time the existence of a type of Arabica coffee, which appeared to be resistant to Elgon dieback, had been demonstrated.

Concurrently with the study of methods for controlling and preventing Elgon dieback, other observations were directed towards finding the cause of the disease by growth observations, which led to experiments on the artificial production of the disease. The results are considered below and recommendations are made for controlling and preventing Elgon dieback.

RESISTANCE AND SUSCEPTIBILITY TO ELGON DIEBACK

Early in the investigations, it appeared that certain coffee trees in the plantations where Elgon dieback was severe were much less affected by the disease, or were even entirely free from it. Although many of the individual coffee trees under observation varied much from year to year in respect to number of stems affected by Elgon dieback, nevertheless, there were found to be consistent differences in resistance and susceptibility to the disease. In one series of a hundred trees, the average number of dieback stems per tree per year ranged from 0 to 46.

In the course of observations on trees in fields of French Mission coffee,* it was noticed that a particular type was consistently resistant to both Elgon dieback and to "hot and cold". These resistant trees were all bronze-tipped with broad and rather coarse leaves. Nearly all the green-tipped trees appeared to be susceptible and so were some of the bronze-tipped ones also. The type with vegetative characters of bronze-tip and broad-leaf, associated with resistance to Elgon dieback and "hot and cold" appears to be similar in some respects to the selection known as "Series A" which was started by Trench [6] on account of its resistance to "hot and cold". It is believed, though, that the resistant type referred to now is not identical with Series A, which latter does not come true from seed, whilst seedling progenies from open-pollinated trees of the Elgon dieback resistant type have been remarkably uniform and resemble their parents in vegetative characters and apparently also in disease resistance.

EXPERIMENTS ON THE USE OF SHADE IN THE CONTROL OF ELGON DIEBACK

General observations made in districts where the disease was prevalent, had shown that in shaded plantations Elgon dieback was absent, or very much less severe than in those where the coffee was grown without shade. The efficacy of tree shade in this respect was demonstrated in a field of unshaded coffee which was severely affected with Elgon dieback. Several different shade trees were established in contiguous plots. As soon as effective shade was present, the amount of Elgon dieback became less and ultimately it was possible to say that shade had cured the disease on those plots, whilst it was still present in neighbouring coffee which was not shaded. In this and other cases where shade trees were found to be effective against Elgon dieback, it was nevertheless impossible to say precisely in what way this had come about, because shade trees are known to affect coffee in numerous ways. Therefore, an experiment was planned in which it was proposed to show whether a shade canopy alone would be sufficient to prevent the disease. The object was to remove the additional and complicating factors associated with natural shade, and to utilize only artificial shade. The procedure and results of this experiment are described below.

Previous experience had shown that artificial shade is not generally a satisfactory method for providing shade on the estate scale. Therefore information was also needed as to the type of natural shade which might be practicable in the control of Elgon dieback. Experiments along such lines were undertaken and are described below.

(1) *Effect of Artificial Shade*

The object of this experiment was to observe whether the number of dieback stems was less on the trees given overhead shade than on those without it. Ten plots of coffee trees were demarcated within an area of approximately two acres at Kapretwa Estate. Later, five of these plots were situated within the shaded area. The remainder were near to those under the canopy but were sufficiently beyond the limits of the shade for it to exert no influence upon them. In the first year of the observations there was no shade over any of the plots. The artificial shade was then erected so that it covered five only of the ten plots during the three succeeding years of the experiment. In order to reproduce plantation conditions, it was considered essential for the canopy to be continuous over a large area, rather than limited to discrete plots. This canopy was at a height of twelve feet above the ground and it consisted of bamboo poles split in half and attached to wires, spaced so that gaps of approximately three inches were left between each split bamboo and the next. This canopy was made as uniform as possible. The amount of direct light from sky and sun reaching the plants under the canopy was estimated to be two-thirds to one-half of the normal.

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* The Arabica coffee known as French Mission, was grown from coffee seed produced at the St. Austin's Mission near Nairobi, this estate was established by seed taken from a few trees at the Bura Mission, where the French Fathers had introduced seed from Aden in 1893. The seed introduced by the French Fathers was apparently mixed, containing predominantly the so-called "Mocha", and other types in which the tip leaves are bronze and not green.

Monthly counts were made of the number of dieback stems on all the trees in the ten plots in this experiment. The results showed a highly significant difference in favour of the shaded trees, compared with the unshaded ones, as regards numbers of Elgon dieback stems.

(2) *Effect of Quick-growing (Temporary) Shade-trees*

An area of coffee was selected within which plots were demarcated at random and recorded for Elgon dieback during two seasons. When these observations had served as a uniformity trial, quick-growing shade-trees (*Vernonia amygdalina*) were planted in some of the plots and the dieback observations were continued. The mean number of dieback shoots per tree (17.7) was less for the shaded plots than for the unshaded ones (22.9), but this difference (5.2) in favour of shade was not statistically significant. General observations on the coffee in these plots left no doubt that the *Vernonia* ("Mororowet') shade was beneficial to the coffee and was effectively reducing the incidence of Elgon dieback in the shaded plots. It seemed probable that the difference in number of dieback shoots between the shaded and the unshaded plots did not reach statistical significance because insufficient time had elapsed between the full development of the shade-trees and the end of the experiment.

(3) *Effect of Slow-growing (Permanent) Shade Trees*

Circumstances made it difficult to complete an experiment in which the effect of a quick-growing shade tree on dieback was to be assessed. The difficulty in the case of a slow-growing type of shade tree has been almost insurmountable. It was only possible to observe the coffee trees under an established tree and to compare them with a number taken at random, beyond the influence of the shade. Nothing was known as to the amount of dieback which the coffee might have had if the shade had not been there. It had to be assumed that these shaded trees and the unshaded ones in the vicinity were both random samples from the same population. Observations lasting over a period of four years were made on two groups of five coffee trees, shaded by large specimens of *Entada abyssinica*. No case of Elgon dieback was observed on any of these ten shaded coffee trees, although neighbouring trees without shade were consistently affected by Elgon dieback. It is concluded that *Entada abyssinica* can be used effectively as a shade tree for the control of Elgon dieback.

(4) *Effect of a Row of Trees*

Single lines of trees are frequently planted as shelter belts for the coffee, *Grevillea robusta* being commonly used for this purpose. General observations had shown that such lines of trees were beneficial in reducing Elgon dieback. Accordingly, an experiment was undertaken to establish whether a shelter belt might serve as a method of control.

The numbers of dieback stems were recorded for four years in a block of coffee through which a line of *Grevillea robusta* was planted in 1935. As a result of these observations, it was found that in 1938 the amount of dieback was significantly less in the coffee, which was then receiving some shade from the line of *Grevillea*, than in the neighbouring unshaded coffee. It was therefore concluded that rows of trees planted as windbreaks were worthy of consideration for reducing Elgon dieback.

(5) *Effect of Coffee as Shade*

It was often observed that when only part of a coffee tree was shaded, any beneficial effect was confined to that portion. This limited effect of such restricted shade is in accordance with observations made by Nutman [8, 9]. He found that for single coffee leaves, the rates of photosynthesis and the stomatal movements were in response to the amount of light which the individual leaf received. Carbon assimilation proceeds in an individual leaf when shaded, but not when in direct sunlight. Therefore it seems likely that in coffee plants of sufficient size, there may be beneficial effects through the mutual shading of leaves, so that parts of the plant are affected advantageously by the shade from certain of its own branches. It seems that the presence or absence of such shade may explain the conical growth-habit of coffee trees suffering from "hot and cold". The tip, with the youngest pair of primaries, receives the most light, lower branches may be expected to receive less in proportion to their distance from the tip. Therefore, primaries at the tip will grow less than primaries lower down, where the growth will tend to be enhanced through the interruption of light by the branches above. Practical use can be made of the beneficial effect from a small amount of coffee shade in reducing the severity of Elgon dieback and "hot and cold" diseases. When coffee is grown on a multiple-stem system, it is often noticed that the tall stems show "hot and cold" symptoms but that the stems below, constituting the next "cycle", are relatively healthy. Attempts have been made to provide shade by retaining one or more of the tall coffee stems, instead of removing them periodically, as would be the natural procedure in multiple-stem pruning. It is believed that this compromise has not been found altogether satisfactory and has not been adopted permanently as far as the writer is aware, nevertheless it does serve as an example of the way in which coffee may be made to provide its own shade. Nutman [10] in expressing the opinion that maximum carbohydrate formation in the coffee tree should be encouraged, suggested that in some districts where much cloud prevails, it may be sufficient to provide shade merely by "so growing the coffee tree that it shades itself". The manipulation of the coffee tree so that it provides its own shade, will not be further considered here as a possible method for controlling "hot and cold" or Elgon dieback, because the writer has not himself carried out experiments with this objective.

GROWTH STUDIES

In growth habit shaded trees differ from unshaded in much the same way as those resistant to Elgon dieback and "hot and cold" differ from susceptible trees. Therefore, it was desirable to obtain data on the sequence of events in the growth of coffee trees which resulted in these growth differences.

In the course of growth observations made on a wide range of Arabica coffee types growing under a variety of conditions, it was found that the time interval between the appearance of one pair of "primaries" and the appearance of the next pair, was in direct proportion to the length of the internodes separating the first pair from the second. Therefore, the longer the period of time between the appearance of successive pairs of "primaries", the greater was the internode length separating them and *vice versa.* A similar relationship was found to occur for the internodes of lateral branches.

The growth habit of Arabica coffee known as "hot and cold", varies much in degree according to the accentuation of such symptoms as "bunched" growth and "leafiness", by which it is characterized. This habit was found to be the result of rapid production of new pairs of "primaries", which leads to their close spacing on the vertical stems; when the internodes in lateral branches are also abnormally short the condition of "bunched" growth is intensified. Observations made on unshaded coffee trees representing both resistance and susceptibility to Elgon dieback and "hot and cold", showed that the difference in growth between these types was comparable to that between shaded and unshaded coffee. The period of time separating the appearance of successive pairs of "primaries" was greater for resistant trees than for susceptible trees.

It was generally noticed that the slower production of new primaries in the resistant type was associated with a lower rate of leaf production, and also apparently with less leaf fall, as compared with the susceptible type. In the course of observing the development of lateral branches on the vertical stems of individual trees over periods up to one and a half years, records were made of the occasions when new leaves were formed and when old leaves were shed. It was found that the length of time during which leaves remained on the trees varied considerably, between a few days and several months. In consequence of this variation, the number of leaves on a vertical stem did not necessarily increase continuously or regularly, but a stage was sometimes reached when the number of leaves lost exceeded the number of new leaves produced. In general, it was found that in the cases of trees susceptible to Elgon dieback when growing without shade, there was only a limited period, which ranged between 167 and 442 days, when the number of leaves on the tree was increasing. Subsequently the number of leaves lost tended to exceed the number of new leaves produced. In the course of the observations made on resistant trees, there was found to be no such limitation of the period during which the number of leaves remained constant or was increasing, because, on trees that remained free from Elgon dieback, the number of new leaves produced kept pace with the number of older leaves that were lost.

The appearance of Elgon dieback symptoms in an individual branch was preceded by one or other of two characteristic growth phenomena. Sometimes Elgon dieback was observed to occur when there had been a steady development of foliage during a period when the rate of production of new leaves was nevertheless exceeded by the rate of loss of older leaves; at other times, it was found that the rates of production and loss of leaves fluctuated greatly during the period immediately preceding the occurrence of Elgon dieback. It would appear that the inference to be drawn from these observations is that Elgon dieback is associated with an "uneconomic" or prodigal manner of growth.

EXPERIMENTAL PRODUCTION OF ELGON DIEBACK

The observation that there was an excessive loss of leaves in trees suffering from Elgon dieback as compared with healthy trees, led to defoliation experiments. It was found that, when the leaves were removed from the whole or part of a coffee tree, there were symptoms in the treated parts which resembled Elgon dieback. A difficulty arose in the interpretation of experiments where the leaves were removed from unshaded coffee plants, because untreated stems, or neighbouring trees which were not treated, might also develop dieback in addition to the defoliated stems. However, it was found that by defoliation, Elgon dieback could be produced even on shaded stems, when the untreated but shaded stems invariably remained entirely free from dieback symptoms, as in the following experiment.

Four multiple-stem coffee trees under shade were used. One of the stems of each of these trees was defoliated and one or two stems left untreated as controls. None of the treated stems was carrying any coffee berries, so that any dieback which occurred could not be confused with that due to overbearing. Two months after defoliation, all the treated stems had developed dieback symptoms, which ranged between one and seven affected branches per stem, but all the untreated stems remained healthy.

THE CAUSE OF ELGON DIEBACK

Whilst observations and experiments on Elgon dieback were proceeding, certain circumstantial evidence accumulated to suggest that this disease, and probably also "hot and cold", were associated with carbohydrate deficiencies in affected coffee trees. In places where Elgon dieback and "hot and cold" were prevalent, it was generally found that when the stems of shaded coffee trees were cut and tested with iodine solution, there was a blue reaction indicating abundant starch. On the other hand, when cut stems were examined from unshaded coffee trees suffering from "hot and cold", or Elgon dieback, there was no visible blue reaction. It was usually observed that trees affected with Elgon dieback or "hot and cold" were otherwise growing vigorously under favourable conditions of soil moisture and fertility. There was some evidence from soil analyses and from fertilizer applications, that there was generally an abundant supply of nitrogen in the soil when Elgon dieback and "hot and cold" diseases occurred.

In the absence of evidence to the contrary, it is the writer's belief that both Elgon dieback and "hot and cold" are due to carbohydrate deficiency, under conditions where the nitrogen supply in the soil is adequate or possibly excessive. Further, the writer considers that the dieback of stems is caused by a critical local shortage of carbohydrate, whilst "hot and cold" is in the nature of a general insufficiency of carbohydrate in the plant.

THE CONTROL OF ELGON DIEBACK

It has been shown above that there is a type of coffee which is resistant to Elgon dieback and that the susceptible varieties are unaffected by the disease when suitably shaded. Therefore, there are two possible procedures for control, either through replacing susceptible coffee trees by plants of the resistant type, or by the provision of shade. The choice will depend on a number of circumstances which vary from one estate to another. Therefore, it is impossible to make generally applicable recommendations.

The advantages and limitations of various control methods will now be considered so that suitable measures may be selected for individual conditions.

(1) *The Use of Shade in the Control of Elgon Dieback*

Although there may be districts where the rainfall is inadequate for the coffee if it has to compete for soil moisture with shade-tree roots, nevertheless at the higher elevations, where Elgon dieback and "hot and cold" occur, the rainfall is generally adequate and may even be excessive, so that in areas where the disease occurs there need be little fear of the coffee suffering from competition for the soil moisture removed by the shade trees, except when certain trees known to be "greedy feeders" are used for shade. Many of the coffee estates at the higher elevations (6,000–7,000 ft.) are liable to damage from hailstorms against which an overhead canopy will give some protection.

Shade is commonly objected to because the trees may restrict the use of draught implements for cultivating the plantation. This disadvantage is off-set by there being little weed growth when the ground is well shaded. In any case the planting may be so arranged that the trees cause the minimum of inconvenience to the use of draught implements.

It might be thought that artificial shade would be the ideal, but it is not entirely satisfactory. Initial outlay and cost of upkeep are strong objections. An artificial canopy lacks some of the advantages derived from shade trees, such as addition of organic matter from the fallen leaves and probably some increase in the soil nitrogen when leguminous shade trees are used. It may be desirable for the density of the canopy to alter during the year, as can happen when a deciduous tree is used, but an artificial canopy has to be correct from the start, because later alterations will usually be difficult or costly. Tree shade can be regulated by pruning and some control over cropping can be achieved in that way.

It is not possible now to enumerate or discuss the different trees that have been used for shade. The subject has been reviewed by McClelland [11], who considered a number of species of trees, suggesting planting distances and also describing the construction of artificial shade. In the course of experiments on the control of Elgon dieback, considerable success has attended the use of quick-growing shade trees on Mt. Elgon. Shade is obtained in from 9 to 12 months from the "Giant Castor Oil" (*Ricinus*), but this begins to die out after about three years. Not so quick, but longer lived is "Mororowet" (*Vernonia amygdalina*) and likewise another local species (*Vernonia holstii*) which has also been tried. These temporary shade trees are surface-feeders and liable to be harmful to the coffee on that account in dry periods or on poor soil. Therefore such species should be used only as temporary expedients and until permanent trees are established.

The choice of permanent shade trees for the higher altitudes is somewhat limited. The writer has no hesitation in recommending "Musembe" (*Entada abyssinica*), an indigenous tree but unfortunately rather slow growing, so that it will not usually give shade in less than ten years from seed. *Acrocarpus fraxinifolius* has proved very satisfactory on Mt. Elgon as a relatively quick-growing tree for providing permanent shade.

(2) *The Use of Shelter Belts in the Control of Elgon Dieback*

In spite of its shortcomings as a shade tree, *Grevillea robusta* has been the mainstay of coffee culture in Kenya. This tree is cheap and easy to establish in the plantation from seedlings in boxes. *Grevillea* is an upright-growing tree, with little tendency to spread laterally, so that it does not naturally provide a good canopy, but growth is fairly rapid and the habit of the tree may be used to advantage in forming windbreaks. It has been shown above that a line of trees can be effective in reducing Elgon dieback but it will not be as efficient as a uniform overhead canopy. A line of *Grevillea* trees will usually overshade the coffee next to it; beyond that a suitable amount of shade may be given; but further rows will not receive enough because a single row of trees will only cast a shadow on the coffee for some hours in the morning, or in the afternoon, when the sun is not high in the sky. It is therefore worth considering whether morning or afternoon shading is the more desirable.

That part of the Kenya highlands which is influenced by Lake Victoria differs climatically from the area east of the Rift Valley, as discussed by Walter [12, 13]. There is a contrast between these two regions in the amount and distribution of bright sunshine. The months of "grey days" are proverbial in the Nairobi district (east of the Rift Valley). West of the Rift Valley and nearer Lake Victoria, there are very few days with continuously overcast skies. Sunshine records are available for Kabete, near Nairobi, typical of the region east of the Rift Valley and for Kampala, in Uganda, representing the Lake climate. When such sunshine records are examined it is found that there is more morning sunshine at Kampala than at Kabete, a difference probably generally applicable to the two areas. It seems that protection of the coffee from the morning sun is desirable in the Lake area, because cloud may be expected in the afternoon, but the reverse in the Nairobi area. The different diurnal distributions of sunshine in the two areas may explain differences of opinion as to whether coffee does better on east or on west slopes.

If coffee is to be grown without uniform shade, it would seem desirable to plant with exposure and windbreaks as follows:—

Lake area.—Topography and/or line of trees to protect the coffee on the eastern side.

Eastern area.—Topography and/or line of trees to protect coffee on the western side.

(3) *The Use of the Resistant Type in the Control of Elgon Dieback*

The resistant type is recommended when there are circumstances which preclude the use of shade as a control measure. The bronze-tip and broad-leaf trees appear to yield well, but it is not certain yet whether they will give coffee of satisfactory quality. It is known that trees of this type characteristically produce coffee with a large proportion of the malformed beans known as "elephants". Therefore, it is not advisable to plant this type extensively, because it may give quantity rather than quality. When the establishment of the resistant type is contemplated, resistant seedlings are obtained by sowing seed derived from bronze-tip and broad-leaf trees. It is not necessary to take any precautions for selfing such parent trees because the majority of the seedlings will be true to type and therefore there will be very little need for rogueing to be done in the nursery. An area of approximately 40 acres was planted at Kapretwa Estate with seedlings obtained from bulk collections of seed and a uniform stand of bronze-tip and broad-leaf trees was secured in that way.

Where land cannot be made available for complete replanting with the resistant type, there are certain compromises through which an area of the resistant type may be established without undue interference with the existing coffee. Such measures will now be considered with their respective merits and disadvantages.

I.—Interplanting with the Resistant Type.—When the existing coffee trees are at a spacing of 8′ × 8′ or wider, it is possible to consider the planting of the new seedlings in the rows between the older plants. The object is to avoid loss of bearing acreage. Ideally, the old trees are removed only when the interplanted ones are bearing their first, or full crop. At the same time, it will probably be inadvisable to allow the growth of the new plants to be interfered with for too long by the competition of the old-established ones. Some discretion will have to be exercised in order to compromise between consideration for the future of the interplanted coffee, and the limitation of coffee production through premature removal of the bearing trees.

Like shade trees, coffee seedlings interplanted may hamper inter-row cultivation with implements and so add to costs by necessitating more hand work.

II.—Grafting with Scions from Resistant Trees.—The possibility of converting susceptible trees into resistant ones by grafting, was an outcome of experiments to ascertain whether resistance was inherent in the vegetative parts of the plant, or if this character was influenced or determined by the root-system. The most direct method of attack on this problem was by observations on reciprocal grafts. Vertical stems only were used for scions and stocks in this work. All possible combinations of resistant and susceptible stocks and scions were obtained for observations in the field. It was found that resistance was purely a matter of the vegetative part above ground. Therefore, if a suitable sucker was taken from a tree known to be resistant and grafted on to a tree suffering from Elgon dieback, then the resulting scion shoot was free from the disease, whilst any new shoots from the root-stock, or from elsewhere below the graft, continued to be susceptible. When a resistant tree was chosen as stock and a sucker from a susceptible tree grafted on to it, then the scion was still liable to suffer from Elgon dieback because no resistance was conferred on it by the root-stock. Provided that a satisfactory union was achieved, there was no effect attributable to the graft itself.

In the early stages of this propagation work, only vegetative material was used. The method employed was cleft-grafting whenever possible, but when the scion and stem from the stock could not be matched in size, the crown-grafting was used. This technique was satisfactory in meeting the needs of scientific study, but the number of trees that could be grafted was limited by the amount of scion material available. This limitation might unduly restrict the employment of grafting on the field scale. Sufficient resistant-type material to give the requisite number of scions would be essential. A census in French Mission coffee has shown that the resistant-type trees are present to the extent of only about 1 per cent. Without some previous manipulation it would be impossible for these to give the scion material necessary to graft on to the remaining 99 per cent of the trees.

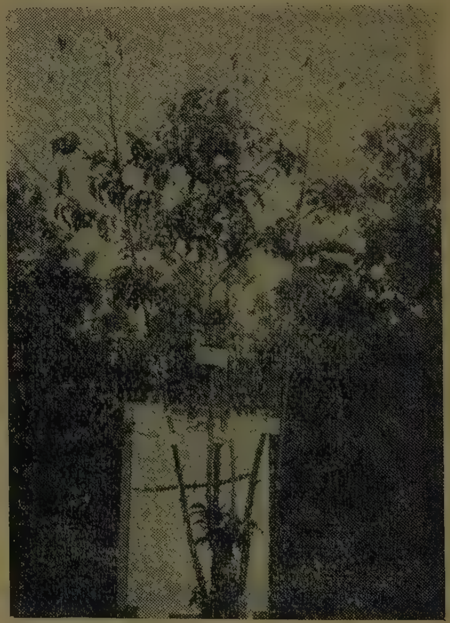

FIG. 1.—GRAFTING: Graft combination of resistant scion on susceptible stock. The stems from the stock severely affected by Elgon Dieback. The scion free from Elgon Dieback.

It has been established that the conversion of coffee trees from susceptibility to resistance towards Elgon dieback can be secured by grafting as shown in Fig. 1, but the use of cleft- or crown-grafting on the field scale is limited by the amount of scion material available and by the degree of technical skill available.

III.—Approach-Grafting with Seedlings from Resistant Trees.—The facility with which resistant-type seedlings may be mass-produced permits a ready means of carrying out large-scale grafting. The technique employed is that known as approach-grafting, the success of which depends upon the scion being on its own roots until the graft has "taken".

The seedlings to be employed should be at least 1½ years old in the nursery; younger ones may be employed but are generally less convenient for handling. At the beginning of the "rains", the seedlings are lifted from the nursery and one or two are planted beside each susceptible-type coffee tree. It is advisable to make a reasonably large and deep hole beside the old plant; it may be necessary to remove some of its roots in order to do this. The seedling is then planted in this hole, which should be arranged so that it is conveniently near a sucker from the stock, suitable for taking the approach graft. A few months later, when it is judged that the seedlings are temporarily established beside the old trees, it is time for the grafts to be made. A slit is cut in the bark of the stock down to the cambium, and only sufficient tissue removed to allow the insertion of the seedling stem, from which a thin slice is removed, thus permitting the two to be in intimate contact for as great a distance as possible, as shown in Fig. 2. The two are bound together with any suitable material, which may then be covered over with grafting wax. If there is much dry weather following the making of the grafts, it may be advisable to cover them over with waxed paper, or any material which will maintain a moist atmosphere there.

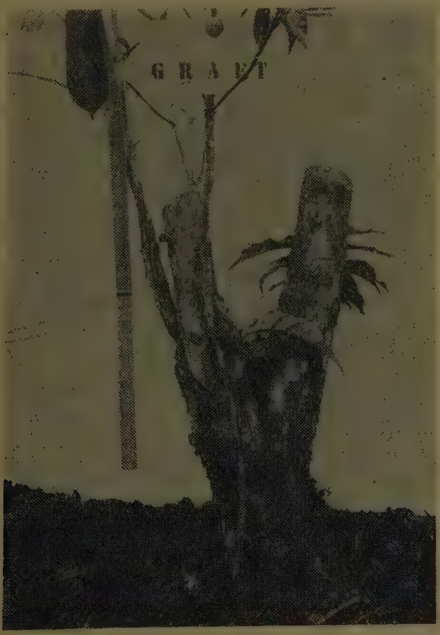

FIG 2.—INARCHING: The graft union effected, but the seedling not yet severed (scale in inches).

When the graft has "taken", the seedling may be severed below the union, and the scion should then be supported by the rootstock alone. When one or more resistant scions have been successfully established by grafting on to a susceptible tree, all other growth from the rootstock is removed. It is a special feature of grafting that there need be no interference with the cropping of the stems from the stock until the scions have developed sufficiently to take their place. When the trees are to be grown on a multiple-stem system, it will be necessary to graft several seedlings on to each stock, or else to graft in such a way that the scion may be "capped" to produce several "verticals" itself.

Compared with ordinary grafting, approach-grafting is relatively fool-proof. It can be carried out satisfactorily by natives, after only a short period of training. The method offers certain advantages over interplanting, or replanting, because it avoids losses of revenue and of original outlay, incurred when established coffee plants are removed.

CONCLUSIONS

The planting of shade trees, and especially the use of the quick-growing ones followed by the establishment of "permanent" trees, is the best and quickest way of controlling Elgon dieback. Where shade, natural or artificial, cannot be employed, the resistant type of coffee should be established without shade.

The writer considers it inadvisable to use the resistant type and to plant shade at the same time. Where shade trees can be grown, and a new variety is to be planted, it would be preferable to employ some selection known to produce coffee of good quality, such as Blue Mountain. This variety is resistant to coffee berry disease [14, 15] and by providing shade, both Elgon dieback and "hot and cold" are avoided also.

ACKNOWLEDGMENTS

This investigation was undertaken at Kapretwa Estate, through the generous hospitality and co-operation of the owner, Mr. T. H. E. Jackson, who has given the writer unlimited scope for experimental work on his plantation. Thanks are due to Messrs. H. B. Swann and J. F. Perkins, Teldet Estates, and to Messrs. R. and J. Anderson, Muroki Estate for their assistance and participation in this work.

SUMMARY

1. An account is given of investigations into Elgon dieback "hot and cold" and related problems of coffee growing at the higher altitudes.

2. The symptoms of these diseases are described. It seems likely that a disease similar to, and probably indentical with Elgon dieback, has occurred elsewhere, notably in Uganda and in India.

3. The fungi isolated from Elgon dieback material are believed to be secondary and not parasitic.

4. The inoculation of coffee with these fungi has not produced the disease.

5. The disease is not infectious. The continued presence of dieback stems does not contribute to the severity of the disease in their neighbourhood.

6. Shade, either artificial or natural, controls Elgon dieback and "hot and cold".

7. The bronze-tip and broad-leaf type of coffee is resistant to these diseases. This resistant type may be expected to give good yields but the quality of the coffee produced may not be satisfactory owing to malformed beans.

8. Differences in manner of growth between shaded and unshaded trees corresponded with similar differences between resistant and susceptible trees, when grown without shade.

9. Elgon dieback generally developed in stems where there had been premature shedding of leaves.

10. Elgon dieback was produced by artificial defoliation.

11. The writer considers that Elgon dieback and "hot and cold" are causally associated with carbohydrate deficiencies which commonly occur in coffee grown without shade, under the soil conditions prevailing where these diseases occur.

12. Practical control and the respective merits of shade or the resistant type without shade, are considered.

13. The susceptible-type trees in a plantation can be converted to resistant ones, by grafting on to them, either the stems from bronze-tip and broad-leaf trees, or the seedling progenies derived from them.

14. Grafting avoids certain disadvantages inherent in replanting or in interplanting.

15. The establishment of shade trees is the best method for controlling Elgon dieback and "hot and cold" diseases.

16. The most desirable course in the prevention of these diseases would be to plant *Entada abyssinica* to provide shade and then to establish a uniform type of coffee known to produce "beans" of good quality. The Blue Mountain variety is proposed for this purpose because of its additional merit of resistance to Coffee Berry disease.

Note.—Since Mr. Thorold completed his studies on Elgon dieback, two important observations have been made which it is considered should be recorded. These are—

(*a*) that whilst the type of coffee referred to by Mr. Thorold as Series "A" is highly resistant to Elgon dieback, areas of this type on exposed sites have succumbed to this form of dieback during the past two years. It is recommended that efficient windbreaks be planted outside the coffee on all such exposed areas;

(*b*) that the variety known as Blue Mountain will not produce economic crops when cultivated under heavy shade. In areas where both coffee berry disease (*Colletotrichum coffeanum*) and Elgon dieback are liable to occur, it is recommended that this variety be planted but that it be subjected to a very light canopy of shade.

S. G.

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NOTES ON CHEESE MAKING

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These notes cover the general principles and practice of cheese-making, in large or small quantities, and can be modified to meet any set of conditions.

THE MILK

The first essential is good clean milk, otherwise no after-manipulation will produce a good-quality, pleasant-tasting cheese. The richness of the milk also considerably affects the quantity of the cheese produced; for instance, if the milk contains 3 per cent butterfat, 11.4 lb. will make one pound of cheese, whilst with milk of 5 per cent butterfat only 8 lb. will be necessary. If milk is obtained from native sources it quickly develops undesirable organisms, so it is better to use only morning milk for cheese-making.

TREATMENT OF THE MILK

As soon as the milk is received it should be strained through two layers of loosely woven calico, and in the case of the evening's milk, cooled to below 75° F. and left overnight in a cool store, so that it does not sour before morning. In the morning, the cream should be skimmed off, warmed and remixed with the milk. The morning's milk is strained, mixed with the evening's milk and the whole left to ripen or develop acidity at ordinary room temperature, unless in a cold area, when it will be necessary to warm the milk to 70° to 75° F.

RIPENING THE MILK

Before the rennet is added, the milk should have developed a certain amount of acidity or ripeness. If a mixture of evening and morning milk is being used, the milk will ripen quicker than morning's milk alone. The period of ripening will also depend on the room temperature. By "ripening", the production of lactic acid is inferred, as a certain amount of acidity is necessary before the rennet can act effectively and produce a reasonably firm curd. The ripeness of the milk is estimated by means of the rennet test, or acidimeter test. For most types of cheese the amount of acidity required varies between .19 and .23 per cent, but with milk from African Zebu cows, wide variations in acidity may be found. For instance, tests have shown that the morning's milk can contain up to .25 per cent acidity soon after milking, whilst the evening's milk may give acidity readings the following morning up to .35 per cent. The reasons for these wide variations from the accepted European standards are not as yet fully understood, but are probably due to the wide differences in the constitution of the milk, together with the action of organisms other than those of lactic acid. However, the figures given in these notes illustrate the advance in the acidity percentages as the cheese-making progresses, and can be taken as a valuable guide. The main point is not to be afraid to build up from the acidity of the milk at renneting time, and to complete the cheese-making within the prescribed periods.

THE RENNET TEST

Measure off 3.55 c.c. or 1 dram of rennet and place in a cup with one or two pieces of clean straw or match sticks; then add 4 oz. of milk at 84° F., stir rapidly for about 15 seconds and note the temperature and the number of seconds which have passed from the time of adding the milk to the rennet until the point when the straws stop moving, due to coagulation. 20 to 24 seconds is the desirable range, depending on whether early- or late-ripening cheeses are being made.

THE ACIDIMETER TEST

This is more efficient than the rennet test, but requires a 25 c.c. burette, a 10 c.c. pipette, some 0.1 per cent Phenolphthalein, N/10 caustic soda and a dish.

The test.—Measure 10 c.c. of the milk into a dish, add a few drops of phenolphthalein and stir. Add the caustic soda drop by drop, stirring meanwhile until a permanent pink colour is obtained. If 2 c.c. have been used, then .01 × 2 = the amount of lactic acid present in the 10 c.c. of milk. So in 100 c.c. there would be 10 times this amount, i.e. .2 per cent lactic acid, which corresponds to a rennet test of 23–24 seconds. This test can also be used to measure the acidity of the whey while cooking the curd.

With practice under regular conditions and in dealing with small quantities of milk, it is possible to work out a routine without these tests, but if large quantities of uniform cheese are required, then the acidity tests are essential.

USE OF A STARTER

In warm weather the milk will ripen naturally, but to develop a uniform routine, or in cold weather, a "starter" will be necessary. A "starter" consists of milk containing, in as pure a state as possible, growing "lactic" bacteria. In most parts of the world starters can be obtained from Dairy Schools and Colleges, ready for use, but a home one can be prepared as follows:—

Well clean the udder of a healthy cow, discard the first milk, which is usually contaminated with undesirable organisms, draw a quart or so of milk into a sterilized glass jar, strain the milk through a cotton-wool pad into a second sterilized jar and place this jar in a clean dairy, at a temperature of about 75° F. In about 24 hours the milk will have soured and be ready for recultivation. This consists in adding a little to some freshly pasteurized whole or separated milk, but the latter is preferable as the milk gets well cleaned in the process of separation and the fat in whole milk is liable to retard the growth of lactic acid bacteria. To pasteurize milk, heat it up to 185° F. and then cool it quickly to 70° F. (It will have been realized by this time that a dairy thermometer is a very essential item of cheese-making equipment.) Pasteurization destroys all the germs, so that when the starter is added the lactic-acid bacteria have a clear field. Before adding the starter, skim off the top and discard, and add the starter to the pasteurized milk at the rate of half a pint to one gallon of milk. This inoculated milk should be kept at a temperature of 70° to 75° F. and well covered for twenty-four hours, when, after skimming off the top, it is ready for use and recultivation again. The recultivation can be carried on every twenty-four hours for some time, but the starter will tend to become weak and it will then be necessary to prepare a fresh one.

The amount of starter added to the milk intended for cheese-making will depend on the acidity test of the milk at the time of adding the starter, and will vary from ½ to 2 per cent. Enough should be added to produce a curd (with rennet) in from seven to eight hours. This means that the starter should be in the milk 1½ to 2 hours before renneting, and the curd should be ready for moulding or vatting within 5½ to 6 hours after adding the rennet. It is better to add a small quantity of starter some time before renneting rather than to add a large quantity just before renneting, since the former method allows the starter organisms to become acclimatized and to overcome unwanted germs that may be present. It also helps to produce a mellow curd. Too much starter added just before renneting will tend to result in a quick granular curd, which will give a cheese poor in flavour and crumbly in texture. The starter should be kept at an even temperature, about 70° F. is best (although this is difficult to obtain in the tropics). If kept too cold the organisms will not develop properly and if kept too warm the organisms will produce too much acidity and destroy themselves—this is the main reason for recultivating the starter each day. When ready for use the starter should have a smooth curdled creamy appearance with a pleasant acid taste, and should show about .8 per cent on the acidimeter. When added to the milk it should be strained through a cloth, so that it will mix well with the milk.

Cheese is sometimes made without the use of rennet, by adding enough starter to the milk to form a curd within a few hours. This method is not to be recommended, as the resulting cheese tends to be sour and of poor texture, due to difficulty in draining the whey from the soft curd, which cannot be cut properly.

ADDING THE RENNET

The amount of rennet added depends on the type of rennet used, the kind of cheese being made, the acidity, richness and temperature of the milk; and the time within which the cheese making operations are to be completed. Rich milk requires more rennet than poor milk. Temperature is a very important factor and is varied with the type of cheese being made, the weather, and also with the kind of milk being used. Higher temperatures are required with rich milk and in cold weather than with poor milk in warm weather. Too high a temperature will result in a curd which is firm before it is acid enough, while too low a temperature will give a curd which is weak and from which excessive fat will be lost, resulting in a hard, dry cheese. If the milk is too acid, sufficient rennet must be added to form a firm curd quickly, otherwise acidity will develop too quickly whilst the curd is being worked, so that a dry, crumbly cheese will result. Standard liquid rennet is usually used in the proportion of 1 drachm to 3 to 4 gallons of milk; it should be diluted with ten to twenty times its volume of water before being added to the milk, and the milk should be stirred for a few minutes to mix in the rennet thoroughly and to prevent cream rising to the top. Over-stirring must be avoided and the period for which it is safe to stir depends on the acidity and temperature of the milk. At 84° F. and acidity .21 per cent stirring can be continued for six minutes, but if over .23 per cent stirring must be stopped after 2½ minutes. When the stirring has ceased the surface of the milk can be gently agitated to prevent the cream from rising until the milk commences to coagulate, which can be detected by the milk hanging on to the fingers after they have been dipped into it. Rennet may also be obtained in a dry form made up into tablets, but in whatever form it is obtained the manufacturer's instructions should be followed in the first place, and, if necessary, modified in the light of experience to meet local conditions and any deterioration of the rennet. Generally speaking, enough rennet should be added to produce a firm curd in 45 to 60 minutes at a temperature of 84° F., but, with some varieties of soft cheese, made with less rennet at a low temperature, coagulation may take from $1\frac{1}{2}$ to 2 hours, and the resulting tender curd is then ladled out instead of being cut with knives.

HEATING THE MILK AND WHEY

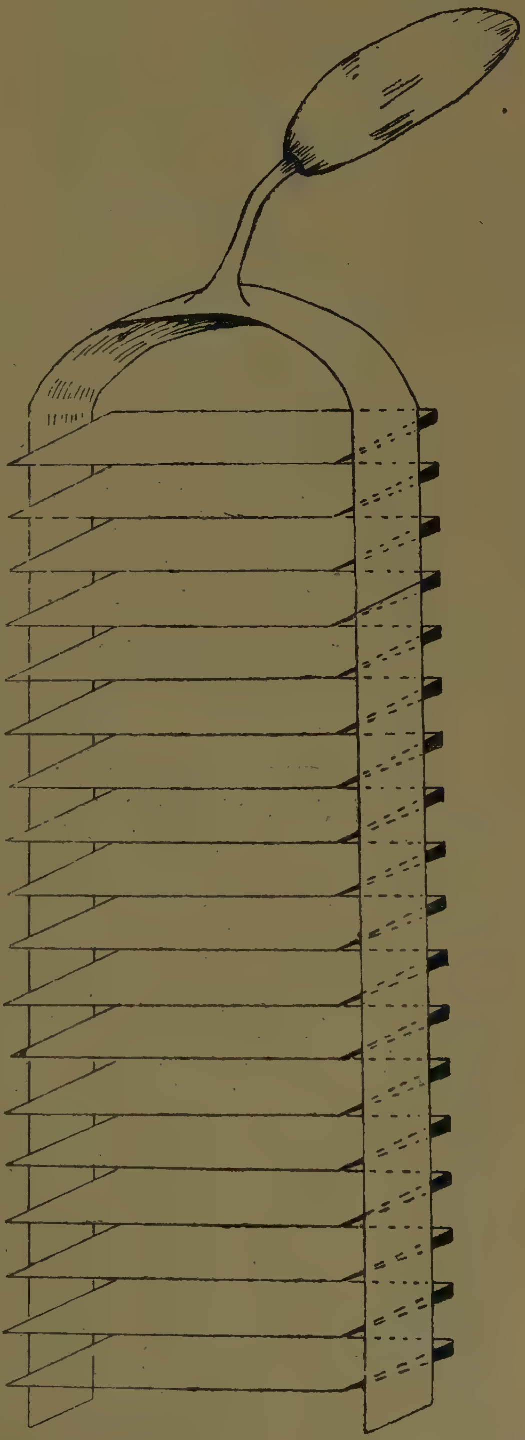
When large quantities of milk are being handled, a vat fitted with a steam or water jacket is required to heat the milk and keep it at the proper temperature during the renneting process, and also to control the temperature of the whey while "cooking" the curd. With small quantities of milk one can improvise by using two buckets or tubs, a smaller one inside a larger with the intervening space filled with hot water as required. Heating the whey may also be done by removing and heating a portion of it and then returning it to the vat, tub, etc. When using this method the whey should not be heated over 130° F. and the curd should be stirred by hand after the whey has been returned. A cloth can be used to separate the whey from the curd, so that the whey can be ladled out; the cloth is spread over the vat and depressed till a pool of whey is formed in the cloth.

WHEN TO CUT THE CURD

To determine when the curd is ready for cutting, insert a dairy thermometer or a finger obliquely into the curd. If ready for cutting the curd will break quite cleanly and the whey on the broken surface will be clear and not milky. Another test is to lay the back of the hand on the surface of the curd near the edge of the vat, and if the curd separates from the side of the vat, leaving no particles of curd on the side, it is ready for cutting.

CUTTING THE CURD

The main point is to take care the curd is cleanly and evenly cut into small cubes without smashing it up. The cutting is usually done by what are called American curd knives, of which there are two kinds, namely, vertical and horizontal, easily made by any tinsmith.

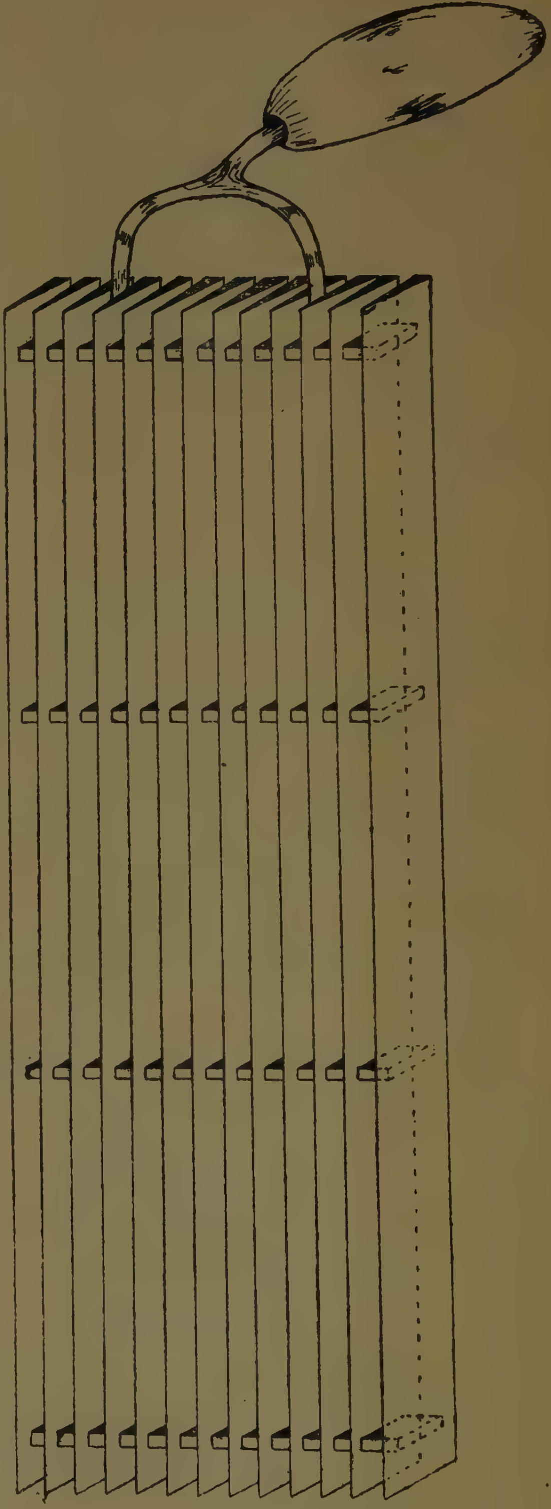


Horizontal Curd Knife

When only small quantities of curd are being cut, a large spatula can be used instead of the regulation knives, while with soft-curd types of cheese a skimming ladle may be used. When using American curd knives the following procedure is adopted. First cut carefully lengthwise with the horizontal knife and then crosswise with the same knife; next cut lengthwise and across with the vertical knife and finally once round the edge of the vat. After cutting, stir the curd gently with the hand for 5 to 10 minutes, by which time the whey should be well separated. During this initial period the temperature should remain at the renneting temperature. With a good curd, properly cut, the whey, after the first few minutes, should be a clear greenish colour; if it is milky the curd has been too soft or badly cut, resulting in a loss of fat. As soon as the initial stirring is completed the whey should be tested for acidity, as the subsequent operations will vary somewhat depending on the acidity of the whey after cutting. It will be found that the whey after the curd is cut contains less acidity than was in the milk at renneting; this is due to salts of an alkaline nature being released during the coagulation of the milk and neutralizing the acidity in the whey, but shortly after cutting the acidity will increase in the normal way.

"SCALDING" OR "COOKING" THE CURD

Scalding consists in gradually raising the temperature of the curd and whey from the renneting temperature up to from 86° F. to 102° F., depending on the type of cheese being made. With some types the temperature is not raised above the renneting temperature, but 96° F. can be taken as the mean "cooking" temperature. In the making of Cheddar cheese the maximum temperature is 102° F., producing a shotty curd, whilst with Wensleydale the temperature is seldom raised over 90° F. and with Stilton not at all. The temperature must be raised very gradually (by one of the methods described under "Heating the Milk and Whey") and at a speed not exceeding 1° F. every three minutes. If raised more quickly than this a tough film will form round the cube of curd before it is properly drained and the curd will be over "cooked" before the necessary acidity has developed. If, on the other hand, the temperature is raised too slowly, there is danger that the curd will be too acid before it is properly cooked. A higher "scald" is required for curd from acid milk or very rich milk than for sweet or poor milk. While the temperature is being raised the curd should be gently stirred to keep the cubes apart. The



Vertical Curd Knife

lower the temperature used for "cooking" the curd, providing the curd is properly firmed, the smoother is the cheese body. A too high or too rapidly raised temperature causes a rubbery, corky cheese. After cooking, the whey is either drawn off or the curd allowed to settle, depending on the acidity it has developed as measured by the acidimeter test of the whey, or the hot-iron test (*see* below) of the curd. Just after cutting the curd the whey should contain about .14 per cent acidity, by the end of the scald this should have increased to .17 per cent, when the curd is allowed to "pitch"—that is, left undisturbed in the whey—so that it will settle and mat together to assist in the development of acidity. If acidity develops too quickly the whey should be drawn off at once. The degree of acidity to be reached before the curd is taken from the whey, or vice versa, depends on the type of cheese being made, and varies from .16 per cent in a quick-ripening, lightly pressed cheese to .20 per cent in a slow-ripening, hard-pressed cheese. If the curd is removed from the whey too soon it is difficult to get it to ripen properly. On the other hand, if it is left too long in the whey it becomes too acid and this is one of the causes of a sour dry cheese.

THE HOT-IRON TEST

This is a simple but very useful method of determining acidity in the curd. All that is required is a piece of flat iron about 1 inch wide by ¼ inch thick, and some 8 inches long, with a wooden handle fitted at one end. The iron is heated to a "black heat" and a piece of curd is squeezed to extract excess water and then rubbed on the surface of the hot iron and withdrawn carefully. The degree of acidity is indicated by the length and fineness of the threads formed as the curd is withdrawn from the iron. Threads ¼ inch long correspond to .17 per cent acidity, 1 to 1¼ inch, fine, threads to .65 per cent (for early-ripening cheese at the milling stage), 1¾ to 2 inches to .9 per cent acidity (for cheddar curd at the milling stage).

RIPENING THE CURD

When dealing with small quantities the curd, after being removed from the whey, is usually tied up in a cloth and put on a draining rack for 20 to 30 minutes then the cloth is opened, the matted curd cut into cubes 6 to 9 inches in length, and tied up again for 15 minutes when it is recut and retied until sufficiently ripe. During the cutting and retying the size of the cubes is gradually reduced until at the last cutting cubes of about 3 inches are made. Cutting the curd assists drainage. If the acidity is developing too quickly for the rate of drainage, weights should be placed on top of the clothful of curd to express excess moisture. When dealing with large quantities of curd the ripening is done in the vat or in a cooler placed in the vat after the whey has been run off. The curd soon assumes a compact mass which is cut into blocks which are piled up three or four layers deep with a piece of cloth between each layer to assist drainage. After 10 to 20 minutes the layers are turned and the blocks piled six to eight pieces deep as they are now spreading out and becoming thinner. This process is continued until the correct acidity is obtained. If the weather is cold the curd should be kept covered with a cloth and not turned very often, otherwise acidity development will be retarded. A small amount of curd requires less cutting and turning than a large amount, unless the acidity is developing too quickly. If the drainage is not keeping pace with the acidity, turn the curd often and put a weight on top to assist drainage. The aim should be to manipulate the curd so that it has drained sufficiently by the time it is ready for moulding. Too much moisture will cause the cheese to crack and too little will prevent the cheese from becoming mellow when ripe.

MILLING

When the curd is sufficiently acid, as shown by the hot-iron or acidmeter test, it is ready for milling. With large quantities of curd a proper milling machine is required, but for home-made cheese a mincing machine will serve. In some cases the curd is merely broken by hand into small pieces. After milling the broken curd is spread out to aerate and then sprinkled with salt. The proportion of salt is usually 1 oz. to 3 lb. of curd, and should be well mixed with the curd by hand. The salt adds to the flavour of the cheese and also helps to preserve it. In addition the salt, while dissolving, reduces the temperature of the curd and makes it ready for vatting or moulding. If the curd is on the wet side, add more salt, and vice versa, as the salt extracts moisture from the curd.

MOULDING THE CURD

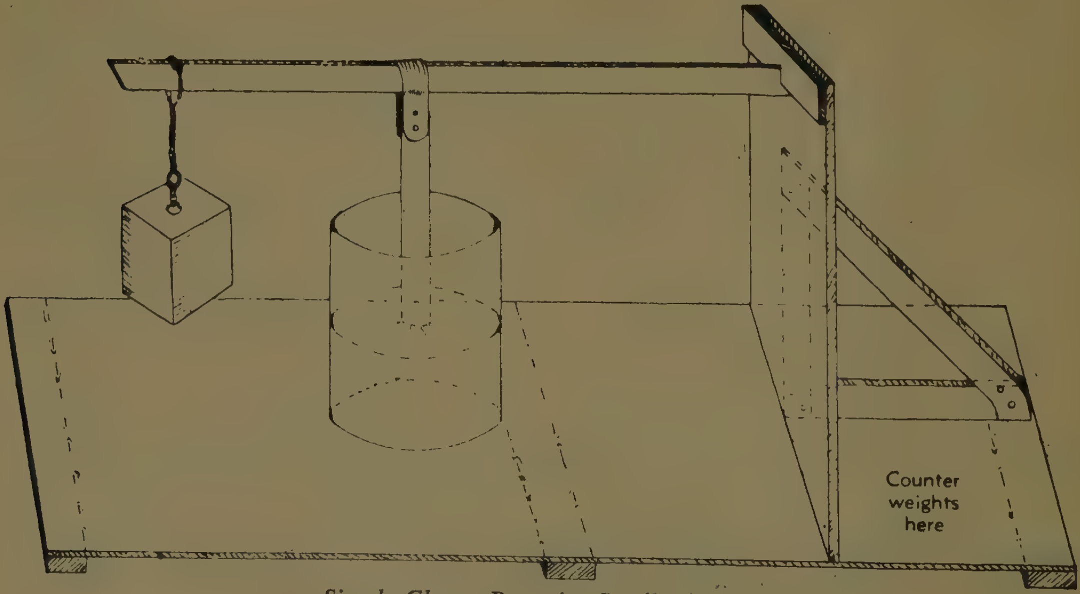
Normally cheese moulds are made of wood or heavy metal, but for home-made cheeses any round tin can be used if the top is carefully removed and holes punched in the bottom and sides. It is advisable to reduce the temperature of the curd to 70° to 75° F. before moulding, or fat will be lost on pressing and the flavour and texture of the cheese spoilt. The moulds are usually lined with cheese cloths before being filled, but small moulds may be filled first and the moulded curd removed by inverting the mould, a suitable sized piece of cloth being placed on the top of the curd and the mould replaced.

PRESSING THE CURD

The amount of pressure applied to the curd varies with the variety of cheese to be made. Tough, firm, acid curd like cheddar must be pressed early under a good pressure, otherwise the curd will not knit together properly. A soft tender curd only requires light pressure and the application of the pressure is delayed for some hours after moulding. In addition the pressure required varies not only with the make but also with the size of cheese being made; for example, a large Cheddar cheese of 60–80 lb. weight would require to be pressed in a proper cheese press capable of exerting pressure up to 25 cwt. whereas small cheeses of from say 3–15 lb. can be pressed in a home-made lever press of the type illustrated, the weight on the lever arm varying from one to five times the weight of the curd in the mould, depending on the toughness of the curd and the rate of drainage of whey from the mould. But whatever pressure is applied, it must be applied gradually, otherwise loss of fat will occur, resulting in a hard coat and poor drainage. Soft, early-ripening cheese only requires a few hours of light pressure while tough slow-ripening curd requires heavy pressure for 3 or 4 days. It is necessary to turn the cheeses in the mould morning and evening and to put on clean cloths. While this is being done the ends can be greased and a cloth cap pressed into position. After the cheese has been pressed it is bandaged, which helps to protect the coat and to preserve the shape. The bandage is usually sewn on or it can be pasted on and the cheese put back in the press to force the bandage on to the coat. If sewn on, the bandage should be sewn into a tubular shape the size of the cheese, then turned inside out and pulled over the cheese for neat fitting. The cheese should be turned daily for the first fortnight in order to prevent the moisture going to one end. After the first fortnight turning every two or three days will suffice.

CONDITIONS AFFECTING CHEESE RIPENING

One of the main factors is the amount of moisture in the curd; generally speaking, the greater the percentage of moisture the quicker the cheese will ripen. Also the rate of ripening depends on the amount of rennet used—the more rennet the quicker the cheese will ripen. A third factor is the temperature of the curing room; within certain limits the speed of ripening can be increased by raising the temperature, but this will cause an increase in loss of weight by evaporation. As will be gathered from the table of comparisons a quick-ripening cheese requires a soft curd with



Simple Cheese Press for Small Cheeses

a relatively high amount of moisture obtained by using more rennet at a lower renneting temperature, followed by a low "scald" temperature and low acidity at drawing of the whey together with less salt at milling, lighter pressure when pressing in mould and a higher temperature in curing room.

MODIFICATIONS EMPLOYED IN MAKING QUICK- AND SLOW-RIPENING CHEESES

	Quick-ripening	Slow-ripening
Temperature of milk at renneting.	Lightly pressed cheeses 82° to 84° F. in inverse proportion to atmospheric temp.	Hard pressed cheeses 86° to 88° F.
Rennet test.	24 secs.	22 secs.
Acidity test.	·19 per cent	·21 per cent
Amount of rennet.	1 drachm to 3 gallons.	1 drachm to 3½ to 4 gallons.
Time between renneting and cutting curd.	45 minutes.	45 to 60 minutes.
Size of curd when cut.	Beans.	Peas.
Temperature of scald.	86° to 90° F.	98° to 102° F.
Time taken stirring and scalding in whey.	35 to 45 minutes.	60 to 80 minutes.
Time "pitched" in whey.	Till acidity reaches ·16 or ⅛" to ¼" long fine threads on hot iron.	Till acidity reaches ·2 or a full ¼" long fine threads on hot hot iron.
Acidity at milling.	·45 per cent or ¾" threads on hot iron.	·85 per cent or 1½ to 1¾" on hot iron.
Amount of salt.	1 oz. to 4 lb.	1 oz. to 3 lb.
Pressing.	Light pressure for 12 hours.	Steadily increasing pressure for 3 to 4 days.
Period of ripening.	3 to 6 weeks.	3 to 6 months.

COMMON FAULTS AND DEFECTS IN CHEESE

Tainted cheese is usually due to the milk being contaminated with undesirable smells or organisms and the remedy is cleaner production methods, cleaner utensils and care in keeping the milk away from any substance having a strong odour.

Spongy curd is usually caused by the milk becoming contaminated with gas-producing organisms, so that the resulting cheese is full of small holes. In bad cases the cheese may swell and burst before ripening is completed. Gas-producing organisms are common in dirty *bomas*, dairies and in dirty water. Cows with diseased udders may also be responsible.

Hard dry cheese may be due to (*a*) too soft a curd due to renneting at too low a temperature or using an insufficient amount of rennet; (*b*) cutting the curd before it has properly set, or careless cutting resulting in excess loss of fat; (*c*) moulding at too high a temperature and pressing too heavily or too quickly.

Sour cheeses may be caused by using over-ripe milk and not hurrying on the cheese-making processes sufficiently to keep pace with the ever increasing acidity. With over-ripe milk, it is necessary to rennet at a higher temperature with more rennet, and to cut the curd into very small cubes to assist drainage. The "scalding" temperature should also be higher and it is not necessary to "pitch" the curd. Whilst working the curd, cut and turn often to cool and apply weights to hasten the expulsion of the whey. A too acid curd should be subjected to higher pressure than usual, and the pressure should be applied quickly.

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RESEARCH AND COLONIAL DEVELOPMENT

Given a sufficiently detached perspective of the inception and trend of British Colonial development, one might well form an impression not differing greatly from that proceeding from a survey of the workings of human nature. There would be disclosed to one's view such elements as curiosity, adventure, courage, need, opportunism, foolishness, erratic behaviour, much remissness, and unwise discontinuity of effort; but there would also be evident a real tenacity of purpose, a growing element of perception and constructiveness, together with a willingness to recognize past mistakes, and, not least, a determination to make good in the future. Those who are familiar with almost any one of our Colonies will be able to fill in the details of the mixed and not always laudable historical scene.

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D. D. T.

By V. A. Beckley, M.A., A.I.C., Senior Agricultural Chemist, Kenya

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It is very certain that few materials have received the free publicity that has been thrust upon the chemical now commonly known as D.D.T. Its news value in the lay Press has rivalled that accorded to penicillin. For a very long time, information regarding its properties and uses had been placed on the "secret" list. It is not surprising that much of what has been published is false and sensational. The veil of secrecy has now been lifted and it is learnt that the Ministry of Information has published a leaflet, correcting the false rumours. Unfortunately, this leaflet has not been received in East Africa, so it would appear desirable to follow suit.

D.D.T. is the chemical *D*ichloro-*D*iphenyl-*T*richloroethane, more correctly 1.1 *bis* (para-chlorophenyl) 2.2.2 trichloroethane. It was first synthesized by O. Zeidler, a young German student of chemistry in 1874. Since it is a very stable compound of no use in further syntheses, it passed into the limbo of such compounds. In 1939, a research worker of the firm of J. R. Geigy of Basle, a firm with subsidiary companies both in Great Britain and the United States, searching for moth-proofing agents, resuscitated the compound and discovered its insecticidal properties. In 1941, the efficacy of the compound against the Colorado beetle was brought to the attention of entomologists in the U.S.A. but, since an effective weapon against the pest was already in use, little notice was taken of it. Later, however, further reports were received of its efficacy against many types of insects and interest developed. No information was vouchsafed regarding the composition of the active agent. Only a prepared insecticide, "Gesarol", containing it was available to Dr. Haller of the United States Department of Agriculture, who extracted, analysed, and synthesized a compound. So encouraging were the results of trials with a small amount of pure material that the stage was set for further developments.

By this time, the shortage of pyrethrum was becoming serious, providing an added incentive for further research on synthetic insecticides. When, towards the end of 1942, a quantity of pure material was obtained from Switzerland, intensive investigation was instituted, which substantiated the claims made by the Geigy firm. Since then, factories have been established for its production, both in the U.S.A. and in Great Britain.

D.D.T. in the pure form is a white crystalline powder, having, according to some people, a faint, fruity odour. It is virtually insoluble in water but soluble to varying extents in many organic solvents. In kerosene, for example, it is soluble to the extent of 8 per cent. It is very slightly volatile, so, being really stable compound, it is persistent. Reports have been made of spray residues remaining effective against insects for as long as 300 days after application! It is purely a synthetic material and does not occur in nature. The basic materials required for its production are benzene, alcohol, chlorine and sulphuric acid.

There are several synonyms for D.D.T., which designation was bestowed upon it by the British and American Governments. The original trade mark of the Geigy firm was "G.N.B.", a contraction of "*G*esarol-*N*eocide-*B*ase", and if the material is made in America, an "A" is suffixed. Whether there is a specific combination of letters for Great Britain is still unknown. The final synonym of the active material is a combination, "GNB-A-DDT". "Gesarol" and "Neocide" are names applied to prepared insecticides made by the Geigy Company and which contain D.D.T.

At least two teams of research workers, totallying about one hundred, have been investigating in the U.S.A. the properties and probable uses of D.D.T. In addition, there have been many groups in Great Britain and in the Empire, together with many on the various fighting fronts engaged on the same problems. It is, therefore, not surprising that in so short a while an immense amount has been learnt of the insecticidal properties of D.D.T. There is no doubt that D.D.T. is a very powerful, versatile insecticide but has certain disadvantages, which will be discussed later and which are only now becoming apparent. It is both a contact and a stomach insecticide, though perhaps its effect as a stomach insecticide should more properly be ascribed to a contact effect as it paralyses the nervous system of the jaws and gullet, making it impossible for the insect to feed.

One of the most spectacular uses of D.D.T. was against lice. The standard anti-louse composition used in the Allied armies was based on pyrethrum. This was most efficacious but had to be used frequently. Any one who knows the general run of the private soldier will realize in what this resulted. Other means of de-lousing had to be used as well. The persistent toxicity of D.D.T. has been called in to assist. Underclothing impregnated with a D.D.T. solution or emulsion, will render men proof against lice infestation and, furthermore, the effect will persist through six to ten washings. A dusting powder, containing D.D.T. is also used for application to the body. Its effect, too, is transmitted to the underclothing. As a result, the average louse infestation in the Allied armies in Europe and North Africa was six per million; amongst German prisoners, it was over 5 per cent.

Even more spectacular was its use to combat a typhus epidemic in Naples shortly after its capture. Typhus is a louse-borne disease and is liable to reach epidemic status if circumstances are such as to lead to dirty conditions. The water, gas, electricity, and fuel supplies of Naples were either destroyed or temporarily out of action. It was also winter. Thus, every factor conducive to dirt and louse infestation was present. Very soon after the epidemic started, the death rate became appalling. Enforced mass dusting of the population with D.D.T. anti-louse powder was instituted and soon the typhus epidemic was conquered. Never before has a typhus epidemic been stopped in winter!

Bed bugs constitute another of the major "minor horrors of war". Combating them by normal methods is difficult and is rendered more difficult by the usual type of army hutments. Pyrethrum in kerosene sprays will clear bed bugs but many frequent applications are needed to destroy the new generations as they hatch. A single, very thorough spraying with a 2 per cent kerosene solution of D.D.T. in most cases eradicates the pest. All the living bugs are killed and, while not a destroyer of eggs, a residual film of D.D.T. on walls, beds, and bedding destroys the young bugs as they hatch.

D.D.T. was early used against flies and remarkable claims have been made for its persistent efficacy against house and other flies. A weapon that will destroy flies and keep down their population will be a boon to mankind. Wauton succinctly sums up their activities in the following words:—

> "They are mostly bred in filth and nurtured in corruption. Whether water-born or not, the Diptera are, in most cases, a pest to mankind. They bite or sting without provocation, for no better reason than that they delight in wickedness. They defile, pollute, and poison because their tastes are as vile as they are varied, and their habits are unspeakably loathsome."

A single spraying of the walls and ceilings of farm buildings has kept down the population of house flies for some months; flies touching the thin film remaining are poisoned and die within twenty-four hours. Cattle sprayed with a solution are protected against biting flies. Those that settle die, resulting in a rapid marked reduction of the numbers of the pest.

D.D.T. is not so valuable when used against adult mosquitoes. It has a very slow "knock-down" effect but a sure kill. Mosquitoes carrying malaria or yellow fever, even if touched by spray particles can, and do, bite, and so transmit the disease. Further, D.D.T. does not excite roosting mosquitoes which thus do not come into contact with the spray. Pyrethrum, on the other hand, strongly excites mosquitoes, greatly increasing the chance of the whole population of a room being struck by particles of spray. It has a very quick "knock-down" and a fairly sure kill. Used in conjunction with pyrethrum, D.D.T. has been of great value in eking out the present short supplies. A spray containing half the normal amount of pyrethrum with a little D.D.T. is as efficacious against mosquitoes as regards "knock-down" and kill as the full strength pyrethrum spray. Some unjustifiable claims have been made regarding the long continued after-effects of the spray against mosquitoes; for example, it has been stated that a single spray of a tent renders it untenable by mosquitoes for over a month. While it does appear that D.D.T. has some repellant effect against mosquitoes, there is no real protection to the occupants of such a sprayed tent.

It is as a larvicide that D.D.T. is of greatest value in anti-mosquito work. By using suitable solvents, effective control has been secured with applications as small as one quart per acre of water surface. The real difficulty would lie in effectively making so small an application. Dusts, containing D.D.T. are also being widely used. These can be easily applied from an aeroplane.

D.D.T. has been successfully used against a host of agricultural pests, varying from Codling Moth and Stalk Borer to grasshoppers, beetles, and ticks. It is, however, not effective against quite a number of other agricultural pests. Perhaps, if a different carrier were to be used, it may prove toxic to them also.

It is very evident that in D.D.T. we have an insecticide of great toxicity and versatility; in fact, in the lay Press, the suggestion has been made that by its wide use, an insect-free world would result. Is this possible or desirable? It has already been found that some groups of insects are resistant to, or even not affected by D.D.T. In any insect population, certain individuals are more resistant to the effect of an insecticide than the rest. Continued use of a single insecticide results in the development of a strain resistant to it, such as has already occurred in both Great Britain and the U.S.A. where certain leaf-eating insects are now found to be no longer affected by arsenical insecticides. It is quite probable that continued use of D.D.T. would result in the development of strains resistant to it.

Not all insects are enemies of mankind or his crops; many are highly beneficial. Bees not only produce honey but they are absolutely essential for the fertilization of fruit crop. A honeyless, fruitless world would be rather dull. Of more importance, in a way, are those insects which are parasitic or predatory upon the pest insects. It is they who normally maintain the balance. Many of these insects are very delicate and it is likely that these would suffer very heavily from indiscriminate use of D.D.T. Resistant strains would then dominate and the position would be worse than before the discovery of D.D.T.

As yet, we know very little of the effect of D.D.T. upon animals other than insects. A wide use of D.D.T. as an anti-mosquito larvicide could very conceivably result in the destruction of fish populations and, in many parts of the world, the fish in dams and lakes are of immense importance in the food supplies of the indigenous population. It is known that the solid D.D.T. is practically innocuous to man but in oil solutions it is absorbed by the skin and does have a very bad effect. It is also fairly poisonous when taken by the mouth. The danger of poisoning by D.D.T. is one which must not be overlooked.

The repercussions of D.D.T. and the other synthetic insecticides upon the pyrethrum industry is a matter of great importance to East Africa. That the immense demand for pyrethrum and the short supply have greatly accelerated investigation into, and search for new insecticides, cannot be evaded. A new material, "666", has made its appearance. The first thing to be faced is that the present high price for pyrethrum cannot be maintained; the economics of the whole industry must be overhauled.

At a competitive price, pyrethrum will hold its own and intensive research now in train will more than probably find wider uses for it. Pyrethrum has many advantages lacked by the synthetics. It is virtually innocuous to man, a few are allergic to it but so are some to eggs. It has the quick "knock-down" essential to household insecticides and, at the same time, a very good kill. That there will be an increased demand for household insecticides is certain; so many have become accustomed to their use in the Army that they will demand sprays in civil life.

It has become fashionable to decry "knock-down" as a mere selling point. It is an essential property in household insecticides. Visualize Bill Smith of Bow, late Royal Fusilier, coming home for his tripe and onions and being bothered by flies. Having become accustomed to the relief given by spraying, he demands the room be sprayed. Should the spray have a poor "knock-down", and he be bombarded by bumbling moribund flies, imagine what will happen to his "old woman"!

Suggestions have been made that pyrethrum can be replaced by the synthetic thiocyanates, which do have a very fair "knock-down". Fortunately for the pyrethrum grower, these compounds have an unpleasant odour, a mixture of stale cabbage water and bad eggs, which cannot be disguised or covered by perfumes. Again, imagine Bill Smith's reaction if such a spray were used when he was having his dinner!

The East African pyrethrum industry must regard these synthetics as a challenge. Pyrethrum of a high quality will have to be produced as cheaply as possible. Research must be conducted on the more efficient use of pyrethrum and its wider application. Such research is either planned or under way.

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BUSH CONTROL AND DEFERRED GRAZING AS MEASURES TO IMPROVE PASTURES

PART I

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INTRODUCTION

Early in the investigational work on pastures at Mpwapwa, it became evident that two of the most effective and perhaps also the most practical means of improving the over-grazed lands of the semi-arid areas of the Territory, were by "resting" on some suitable deferred grazing plan and by keeping the woody growth (trees and shrubs) within reasonable control by weeding. These woody species, if not controlled, rapidly invade abandoned cultivations in nature's efforts to regenerate the climax bushland associations of these areas.

With the object, therefore, of obtaining more definite information on these two important factors affecting pasture management in these areas an experiment was started in 1938. This experiment was necessarily simple in design as the funds available for the work were limited. The supervision of the experiment too, owing to absences on leave, secondment and to war-time conditions, has not been altogether satisfactory, but nevertheless the results from the various treatments are most striking. As these may be of interest to readers of this Journal, it is proposed to describe them in this report and at the same time take a final opportunity of discussing their practical significance to East African agriculture in the wider sense of this term.

It may first be helpful to give a brief picture of the general conditions for those who have not visited this station, which may be rather out-of-the-way but is interesting and perhaps useful to workers and others concerned with land utilization in East Africa.

CONDITIONS AT MPWAPWA

Climate.—The Mpwapwa climate is reasonably representative of the semi-arid area (annual rainfall 20–30 inches) of north-central Tanganyika. This is an area of vast peneplains, bounded on their east by precipitous scarps and studded here and there with remnant hills or mountains. The general lie of the land, owing to tectonic upheaval, slopes fairly sharply from east to west. Thus with the prevailing winds from an easterly direction, the greater part of this area lies in a "rain-shadow" with a climate more arid and a rainfall more erratic than that of the rest of the Territory. The average rainfall at Mpwapwa during the past twenty-three years has been 26 inches per annum with a variation from a minimum of 17 inches to a maximum of 38 inches per annum. The rainy period usually commences in December and ends in April, a period of only five months, with a break of as much as six weeks in January and February. A large part of the rainfall falls as heavy thunderstorms and the soils require a good vegetation cover to assist them to absorb the vast quantities of water with which they have at times to cope with in a limited time; otherwise the run-off and soil erosion rate can be very high indeed [8].

Geology.—The parent rocks seem noticably to affect the soil and vegetation of this semi-arid area, in which there are three main geological formations: the Lower Basement Complex of gneisses, schists and granulites in the east; the Younger Granite intrusions in the west and the Youngest Volcanic lava flows, tuffs and agglomerates in the northern tip. Mpwapwa is located in the first of the three groups, the soils of which appear to be rather more fertile than the granite sands but considerably less fertile than those derived from the lava flows, which are comparatively recent (in geological time).

Soils.—The soils of the Mpwapwa area have been described by Temperley [11] who has incorporated the work of Milne. The actual experimental area has a bright red, sandy loam soil and to quote from Temperley: "belongs to Milne's group of 'non-laterized red earths' of the sub-type that has been transported. Milne points out that these soils are not accumulating at the present time but were formed during climatic conditions more humid than now, from material washed down from the highlands. They are leached sandy soils, the clay fraction having been transported further from the hills and accumulated in the bottom lands on which the present alluvial deposits rest".

These red soils in Ugogo are usually of exceptional depth and continue to produce crops, with decreasing yields, even with the removal of the surface soil by erosion year after year, until finally the decaying rock strata beneath are reached. This latter condition is becoming more and more evident in the occupied areas.

Vegetation.—The vegetation of Mpwapwa has been recently described in an excellent paper by H. E. Hornby and R. M. Hornby [2] and I cannot do better than refer readers interested in a detailed description, to this publication. The most prevalent type of vegetation at Mpwapwa is Deciduous Bushland and for a general description of this, which is also the climax type over the greater part of the 20–30 inches rainfall area in the Territory, I quote from Hornbys' paper, page 38: "Throughout this climax the prevailing life forms are short-boled trees to about twenty-five feet in height, often with widespreading branches, and many-stemmed bushes, fifteen to twenty feet high. The crowns of these are usually touching or interlaced, and scandent shrubs and woody herbs from two to five feet high, are evident in inverse proportion to the density of the canopy above, whilst herbs and grasses, forming the lowest stratum, are sparse except along game paths and in the occasional glades. Above the general canopy emerge the crowns of scattered larger trees, to about thirty or forty feet in height, but it is the low trees and the bushes which give the characteristic appearance to the Bushland; one of shady leafiness during the rainy season and of grey-stemmed leaflessness throughout the dry season.

'Dry Thornbush' was the name given to this deciduous vegetation as a whole by some earlier writers. Actually, besides the *Acacias*, comparatively few species carry true thorns; it is the spikey branches of some of the *Albizzias*, and the soft spines of most of the *Commiphoras* that give the thorny impression, while the papery peeling bark of the Commiphoras accentuates the general appearance of desiccation during the dry season, when the earth of 'red Ugogo' reflects the heat of the midday sun. Below and among the bushes a carpet of dry leaves forms to the limited extent permitted by termite activity, but there is no fuel for fire in the sap-filled bushes and shrubs themselves; fires sweeping down from the open woodlands die out as soon as they reach the bushland. Occasional tall candelabra Euphorbias are the only noticeable evergreen trees".

The more important or prominent tree genera are: *Adansonia* (the Baobab, more prominent than prevalent), *Acacia, Albizzia, Commiphora, Cordyla, Euphorbia.* Shrubs include members of the following genera: *Grewia, Marsdenia, Croton, Ormocarpum* and *Disperma.*

Where the trees and shrubs form their maximum density, ground herbage is sparse, but with secondary Bushland following the shifting cultivation usually practised by the natives in this area, annual grasses and weeds can be prominent; the more important species are given later in dealing with the experimental plots themselves.

DESCRIPTION OF THE EXPERIMENTAL AREA

The experimental plots occupy two adjacent areas each ten acres in size. Prior to the year 1928, the land for many years was used by the local Gogo inhabitants and owing to its proximity to Mpwapwa township, from where it is about a mile distant, it is probable that the land for a number of years was used mainly for the growing of crops. In 1928, native cultivation in the area ceased as the land was taken over by Government and since 1930 it has formed part of a departmental stock farm.

During the period 1930 to 1938 the secondary Bushland area was lightly grazed by cattle but otherwise untouched. The grazing helped to maintain a fairly open condition of the vegetation, particularly of the low shrubs, although permitting the trees and taller shrubs, particularly of the thorny species, to develop to their normal size and height.

In 1932 the area for the grassland plots was cleared, burned and stumped and in 1933 it was planted with the strong-growing and hardy type C of the indigenous Star Grass (*Cynodon plectostachyum*) [6]. Roots of this grass were planted with an espacement of two paces by two paces apart. Through pressure of other farming operations the planting was done in April, that is towards the end of the rains, and notes made subsequently recorded a take of only about five per cent for the area as a whole, but about a twenty-five per cent take on the earth bank of a storm drain made on the top side of the cleared area. This ran parallel with the secondary Bushland block above except that it cut through the top left-hand corner of the grassland area to obtain sufficient fall.

Subsequent to clearing, the land was periodically weeded of any woody regeneration and grazed on a rotation. Under this treatment the Star Grass plants which had survived, slowly spread by the runners rooting at nodes. There was also ample opportunity for this grass to invade the adjacent Bushland plots if conditions there were suitable for its growth; actually such invasion has taken place in the growing season but the plants have invariably died out in the following dry season. In 1938 by far the greater part of the herbaceous growth was still provided by annual grasses with a liberal admixture of annual weeds.

LAY-OUT AND GRAZING TREATMENT OF EXPERIMENTAL PLOTS

In 1937, the plots were fenced off and formed two adjacent series of five two-acre plots. The area as a whole is very uniform and has a gentle slope from north to south; the Bushland plots are above with a storm drain, previously mentioned, between them and the grassland plots below.

Treatments.—Grazing of the plots was started at the beginning of the 1938 season, and from then to the end of 1943 the grazing plant is given below; owing to the war and consequent difficulties in providing adequate supervision throughout, a few mistakes occurred, but in general the treatments were carried out satisfactorily:—

Plots 1.—Rested (not grazed) for the first half of the growing season, i.e. December to February.

Plots 2.—Rested the whole of the growing season (from December to June).

Plots 3.—Grazed throughout the growing growing season at half the intensity of that given to Plots 1 and 5.

Plots 4.—Treatment the same as for Plot 2.

Plots 5.—Rested the second half of the growing season (March to June).

The grazing was carried out by putting two fully grown native Zebu oxen, each weighing between 700 to 800 lb., in each plot for a specified number of days a week. If towards the end of the dry season a plot was not reasonably well "cleaned up", additional oxen were put in. At first the cattle were left to sleep in the plots and only taken out to water, but one night two were killed by lions, since when they are put in early in the morning and taken out in the evening. They are watered and they sleep in a lion-proof *boma*. At the beginning of 1944 the grazing plan for some of the plots was changed as will be explained later.

In each of the grassland Plots 1 and 5, the two oxen were grazed four days a week during the growing-season months and this rate of grazing continued in the dry season as long as the plots were able to provide a reasonable amount of feed for them. Actually, except in the first and second years of the experiment, the grassland plots were able to maintain this rate of stocking and since 1942 it has been increased, particularly with Plot 5, owing to the increased carrying capacity.

The Bushland series were grazed on the same plan as the grassland series but at the commencement of the experiment, at only half the intensity, that is two days a week for Plots 1, 2, 4 and 5 and one day a week in the case of Plot 3. As however, the oxen, except during the flush period of growth, were not able to fill themselves satisfactorily and difficulty was experienced in keeping them in the plots, the grazing intensity in these plots was reduced to only one-fourth of that laid down for the grassland series at the start of the experiment. Even so the oxen went short of feed during part of the dry season.

Changes in the grazing treatments made at beginning of 1944.—At the end of 1943, the results were so unsatisfactory, from a pasture view-point, from non-grazing during the first half of the growing season and for the whole of the growing season, that it was decided to make certain changes in the treatment in some of the plots. Accordingly, as from the beginning of 1944, the following changes were made. Firstly the secondary Bushland plots were renumbered so that Plot 1 of the series is opposite and adjacent to Plot 1 of the grassland series. This was done to avoid mistakes which were sometimes made by the African in charge of the routine grazing. Secondly, Plots 1 and 2 of each series are now being grazed on what is known in this Territory as the "chess-board system of deferred grazing". A gate has been made between each pair of plots and one plot of each pair is rested from March to June one year and the second plot rested for this period the next year, the first plot the following year and so on. This should afford information on the efficacy of this system of deferred grazing as compared with the "seasonal system of deferred grazing" (*see* below under heading "Discussion").

RESULTS

When the investigation was planned, it was intended to carry out quadrat studies of the changes taking place in the vegetation, but these unfortunately were not possible owing to my absence from Mpwapwa most of the time the experiment has been in progress. Certain differences are, however, so striking to the eye that they do not need careful analytical methods for detection. Before enumerating them a general description from a pasture view-point, of the two series of plots at the commencement of the experiment will be given.

Bushland plots.—The dominant feature of the vegetation in these plots was the trees and shrubs, which were up to about 25 feet in height. Visibility was confined to a matter of twenty to thirty yards, but the vegetation was open enough to permit the oxen to roam at will about the plots, although tending to confine themselves to tracks winding amongst the trees and shrubs. The ground cover was sparse and composed chiefly of annuals of scanty growth. The more prevalent grasses were: *Aristida adscencionis, Urochloa trichopus, Dactylotenium aegypticum, Setaria pallidefusca,* and a number of others. The annual weeds belonging chiefly to the family *Acanthaceae.* A most important feature of the ground herbage was the almost entire absence of perennial grasses, the only exception being a very occasional tuft of *Eragrostis margaritacea* in the more open patches.

The feed provided by this type of pasturage consists partly of the rather scanty ground vegetation and partly of browse from the palatable and non-thorny trees and shrubs. In the dry season, fallen leaves from the branches too high to browse and the fallen edible pods, chiefly *Acacia spirocarpa* and *Dichrostachys glomerata,* are important additions to the diet. The plots in fact were typical of the best of the native bushland grazing in the vicinity; by "best" is meant having a maximum carrying capacity for this type of pasturage and, owing to lighter use, having also sufficient ground cover to prevent severe soil erosion during the rains (*see* photographs Nos. 4, 5 and 6).

Grassland plots.—In February, 1938, Plots 1, 2 and 4, which were not being grazed at this time of the year, presented a uniform and dense stand of *Urochloa trichopus* about three feet high. Later on in the season other annual grasses became more conspicuous, the more important being *Dactylotenium aegypticum, Digitaria gazensis, Setaria pallidefusca, Harpachne schimperi, Chloris pcynothrix, C. virgata,* and *Aristida adscencionis.* With the exception of the last, these are all useful pasture species, the best being perhaps *Urochloa* owing to its yielding ability and leafiness. If not eaten, however, during its period of growth this grass, in common with other annuals, tends to break down and disappear, largely through being eaten by termites; its value as feed for stock tends therefore to be lost if the pasture is not grazed during the first part of the growing season.

Perennial grasses were represented by a moderate amount of Star Grass (*Cynodon plectostachyum*) and occasional plants of Spear Grass (*Heteropogon contortus*), Beard Grass (*Bothriochloa insculpta*) and *Eragrostis margaritacea* (a perennial relative of Teff Grass). *Stylosanthes bojeri,* a palatable leguminous plant with a prostrate habit of growth and affording valuable feed, was the most important representative of the perennial herbs, other than grasses.

Annual weeds made up the remaining important part of herbage in the grass plots, the more frequent representatives being *Leucas martinicensis, Ipomea* spp., *Cleome hirta* (a species with an objectionable smell when crushed, but a favourite pot-herb of the Gogo), *Bidens linearifolia, Crotalaria cylindrostachys* and many others, including the white-flowered *Astrochlaena hyoscyamoides* which forms so striking a feature of the Ugogo countryside at the end of the rains. All these species are eaten by cattle if they cannot get an abundance of grass.

In the plots grazed during the growing season, the annual grasses were eaten more readily in their flush period of growth, than either the perennial grasses or weeds. As explained before, accurate quantitative analyses were not made of the botanical composition of the herbage, which in any case with a high percentage of annual species varies with the time of year and also from year to year irrespective of any grazing treatment. A rough estimate, however, of the herbage produced in the grass plots in the first year of the experiment is: annual grasses, 65 per cent; perennial grasses (mainly Star Grass), 10 per cent; annual weeds 20 per cent; perennial herbs, 5 per cent.

The general condition of each plot after six years of treatment can now be described.

SECONDARY BUSHLAND PLOTS

Plot 1 (Rested the first half of the growing season).—

The general appearance of this plot is much the same as at the start of the experiment except that the woody vegetation has thickened up noticeably. The protection from grazing during the first half of the growing season, permitted the free growth of the annual grasses and weeds and maintained a good supply of seed. Good use was also made of the supply of browse which remained green for about the first three months the plot was grazed. The protection of the soil in this plot seemed to compare fairly favourably with any of the other treatments, but even so, the soil surface between the trees and shrubs was pretty bare of any vegetation by the end of the dry season and the early heavy rains were followed by marked signs of run-off and sheet erosion.

Plot 2. (Rested during the whole of the rains).—

The remarks made in regard to Plot 1 apply to this plot as well, the thickening up of the woody vegetation being rather more noticeable (*see* photograph No. 5 of a plot receiving the same treatment). Even with this favourable treatment run-off and sheet erosion were evident, although perhaps not so extreme as in the plots grazed during the growing period. The treatment also appeared to supply the greatest quantity of feed for dry-season use; the carrying capacity in terms of grazing days, appeared to be lower than with any other of the treatments, as would be expected owing to the breaking down of the annual herbage and leaf fall, a large proportion of which is also consumed by termites. However, this system of deferred grazing seemed on the whole to give slightly better results, with this type of pasturage, than any of the other treatments in the experiment in protecting the soil and improving the ground cover.

Plot 3 (Lightly grazed throughout the growing season).—

This treatment appeared to maintain the most open conditions of the woody vegetation but led to a reduction in the annual grass and herb cover, due, it appears, partly to these species being prevented from seeding. By making fuller use of the browse during the flush period of growth, the plot appeared, however, to afford the best keep as far as the animals were concerned, although the smallest reserve of dry season feed. Signs of run-off and sheet erosion were most marked, on the other hand, in this plot.

Plot 4 (Rested the whole of the growing season).—

The remarks on Plot 2 apply equally well to this plot.

Plot 5 (Rested for the second half of the growing season).—

Thickening up of the woody vegetation was not so noticeable with this treatment. The ground cover, however, is poor because the comparatively heavy grazing each year in the early part of the growing season, the time of year when the most prevalent species (*Urochloa*) seeds the most freely, seemed to have a particularly adverse effect. The treatment appeared to lead to as severe run-off and erosion as with year-long grazing. The reserve of feed for the early dry season, however, was noticeably greater than in the continuously grazed plot.

GRASSLAND PLOTS

Plot 1 (Rested during the first half of the growing season).—

In contrast with the secondary bushland plots, this treatment appeared to give about the worst results of any of those under trial, although most writers dealing with the subject of pasture management usually advocate resting at this time of the year with the object of producing a good seed crop. In this plot, it is true, the annual grasses seeded very freely indeed, but in permitting them to do so they were apparently enabled to compete too strongly with the struggling perennial grasses and retard their growth. Grazing during the second half of the growing season appeared to inhibit still further the growth of the perennial species, as by this time the annuals had to a large extent matured and had lost their palatability. Star Grass, however, in spite of this, slowly made headway and it is estimated that the percentage of growth made by perennial grasses in this plot in the 1943 season was between 15 and 20 per cent. The proportion of weeds does not appear to have been affected appreciably by the treatment. No visible signs of run-off or sheet erosion could be detected.

Plot 2 (Rested during the whole of the growing season).—

The smothering effect of the early flush of annual grasses on the perennial grasses was very noticeable also in this plot. Star Grass seemed, however, to make better headway during the latter part of the growing season and it is estimated that it produced some 25 per cent of the total growth made in this plot in 1943. The freedom from grazing during the growing season also seems to have encouraged the growth of the weeds, particularly the Labiate *Leucas martiniencis* (*see* photograph No. 3 of Plot 4, which had the same treatment). It seems these are kept in check more by the effect of trampling, as they are not grazed to any extent if plenty of grass is available. The dry "chaff" from the Star Grass provided some useful feed right up to the end of the dry season. No visible signs of run-off or erosion could be detected.

Plot 3 (Grazed throughout the growing season).—

The grazing intensity here, it should be remembered, was comparatively light and at no time during the growing season were the animals in any way short of feed (*see* photograph No. 2). With closer use it is probable that less favourable results would have been obtained. As it is, the plot except at the end of the growing season, when weeds tend to be prominent, has a good vegetation cover and no signs of run-off or sheet erosion could be detected. Star Grass has increased very appreciably and, it is estimated, contributed some 40 per cent of the growth made in this plot in 1943.

Plot 4 (Rested during the whole of the growing season).—

This plot presented very much the same appearance as Plot 2, which receives the same treatment, except that there is rather less Star Grass (due probably to the good take of this grass on the bank of the storm drain in Plot 2 as already mentioned) and the weed *Leucas martiniencis* was rather prominent, possibly as the result of there being less Star Grass (*see* photograph No. 4).

Plot 5 (Rested the second half of the rains).—

This treatment has quite obviously given the best results in carrying capacity (*see* Table 1); in protection to the soil; in control of weed growth (*see* photograph No. 1; and in encouraging the growth of the perennial Star Grass, which is the outstanding species from both the pasture and soil conservation viewpoints. It is estimated that this grass provided over 60 per cent of the feed provided by the plot in 1943 and annual weed growth was reduced to about 18 per cent. The plot afforded 408 grazing days in 1943 and there is every indication that it will do even better in 1944 and should give a carrying capacity of about a beast to 1½ acres.

CARRYING CAPACITY

The number of grazing days afforded by the various plots between the years 1938 and 1943 inclusive, is given in Table 1. It may be said that the grazing of the grassland plots during the years 1939 to 1942 was on the light side and permitted all plots to improve in carrying capacity. In the bushland plots, the grazing during the growing season was light but by the end of the dry season all available leaf and chaff had been eaten and the ground between the shrubs and trees left bare.

TABLE 1

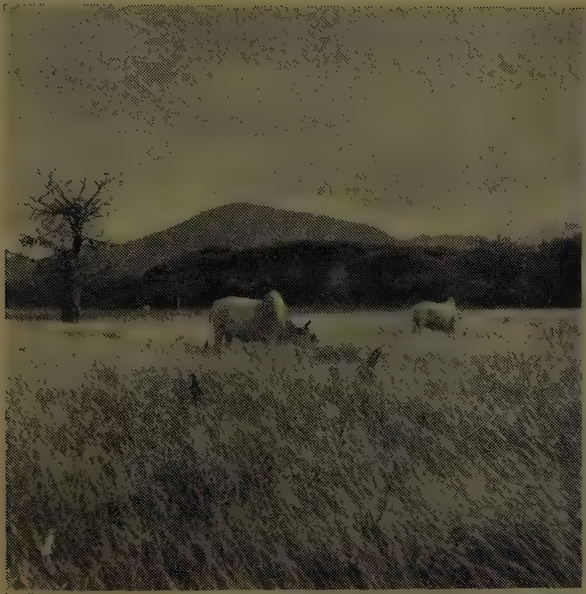
GRAZING DAYS PER ACRE

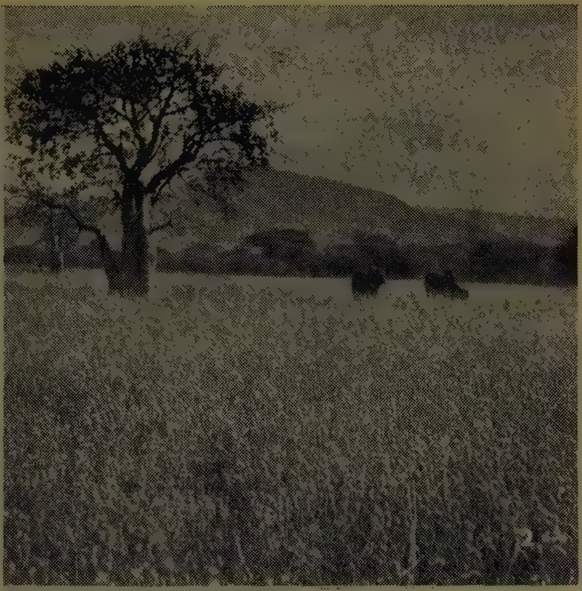
Grassland Plots

Year	Plot 1 (Rested Dec. to March)	Plot 2 (Rested Dec. to June)	Plot 3 (No resting)	Plot 4 (Rested Dec. to June)	Plot 5 (Rested March to June)
1938	104	104	104	104	104
1939	104	104	104	104	104
1940	104	104	104	104	104
1941	104	104	104	104	104
1942	120	120	128	120	156
1943	124	124	156	124	204
Secondary Bushland Plots					
1938	40	40	46	40	40
1939	26	26	26	26	26
1940	26	26	26	26	26
1941	26	26	26	26	26
1942	26	26	26	26	26
1943	36	26	26	26	26

NOTE.—Plot 1 of the bushland series was by mistake partly cleared in 1942, hence the increase in carrying capacity as the result of the freer growth of the annuals.

(*To be continued*)

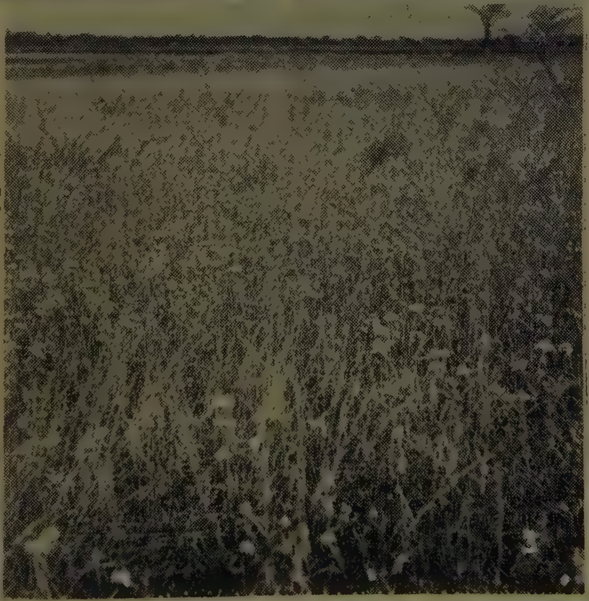




PHOTOGRAPH No. 1.—Grassland Plot 5, July, 1944. This plot was well grazed for half the growing season and rested the other half. Note good stand of grass, chiefly Star, and comparative absence of weeds. The secondary bushland plots are in the background.

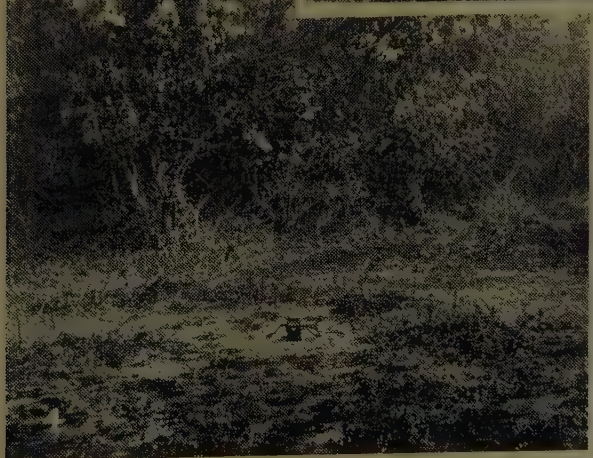
PHOTOGRAPH No. 2.—Grassland Plot 3, June, 1944. This plot has been lightly grazed throughout the growing season. Note prevalence of weeds but fair grass cover.

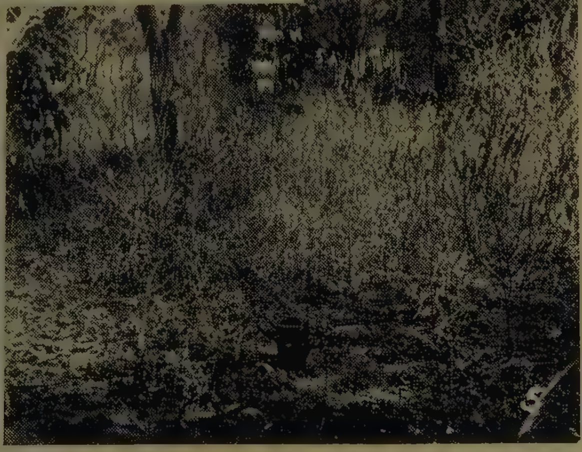
PHOTOGRAPH No. 3.—Grassland Plot 4, June, 1944, rested throughout growing season. Note prevalence of weeds and poor vegetation cover. The grazing, in quantity and quality, afforded by this plot compares most unfavourably with the adjacent Plot 5 (see Photograph 1).

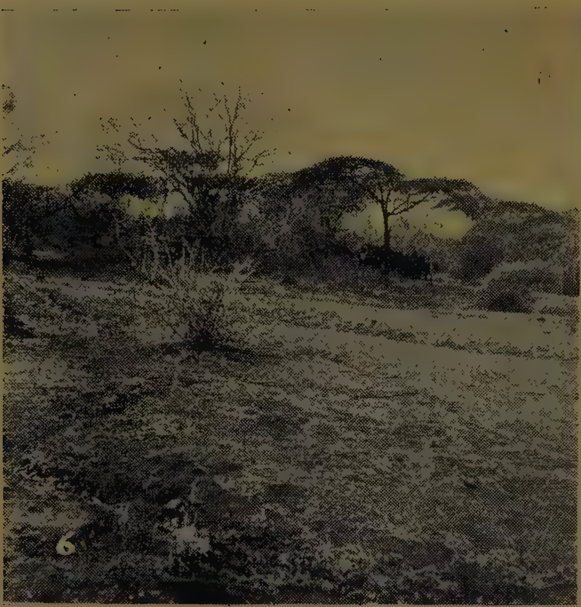


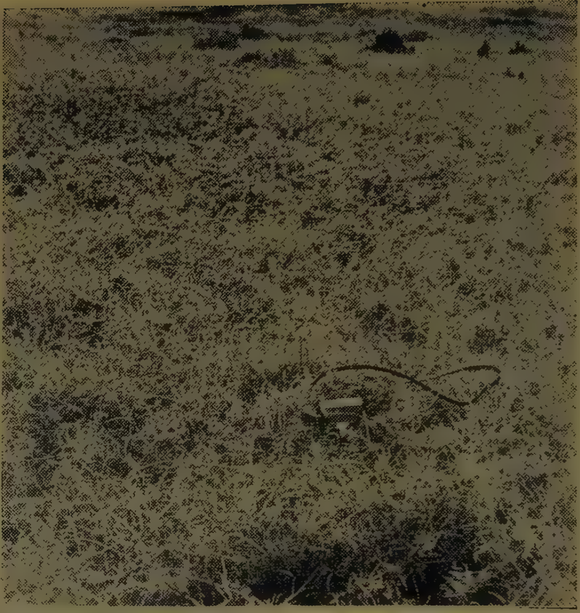
PHOTOGRAPH No. 4.—Secondary Bushland Plot 3, June, 1944. This plot has been very lightly grazed throughout the growing season. Note bare ground and signs of sheet erosion.

PHOTOGRAPH No. 5.—Secondary Bushland Plot 4, July, 1944. This plot has been rested the whole of the growing season. Note somewhat better ground cover of annuals than in Plot 3 (Photograph No. 4) but still very poor as compared with adjacent grassland plot (Photograph No. 3).





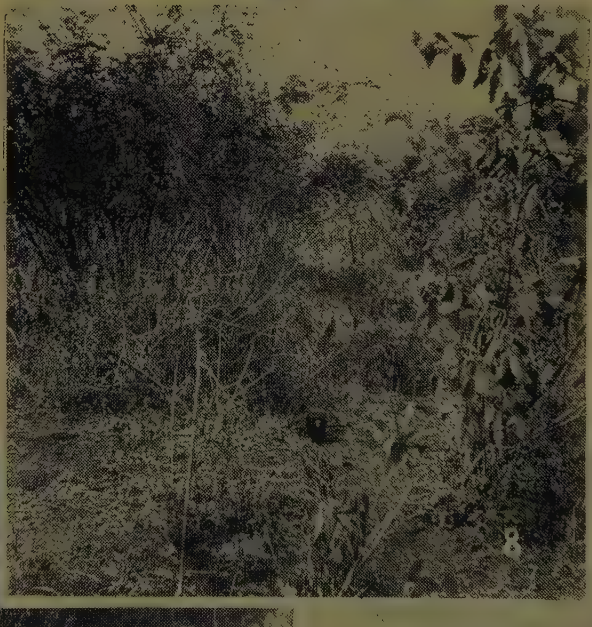




PHOTOGRAPH No. 6.—Typical secondary bushland grazing in vicinity of Mpwapwa in June, abandoned from cultivation for about 14 years. Note paucity of ground herbage and severe sheet and donga erosion.

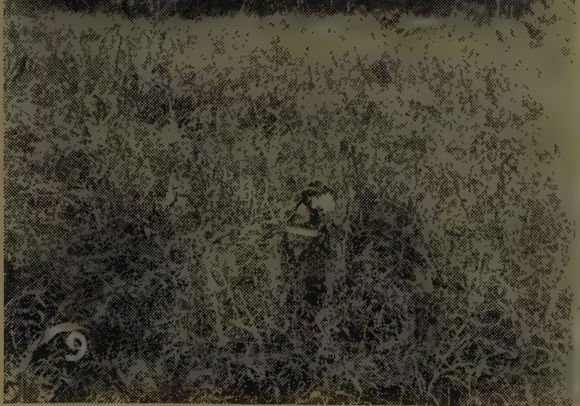
PHOTOGRAPH No. 7.—A well-managed Star grass pasture at Mpwapwa, capable of carrying well a beast to 1½ acres of land without loss of fertility or soil. Ten years previously this land resembled closely that shown in Photograph No. 6.

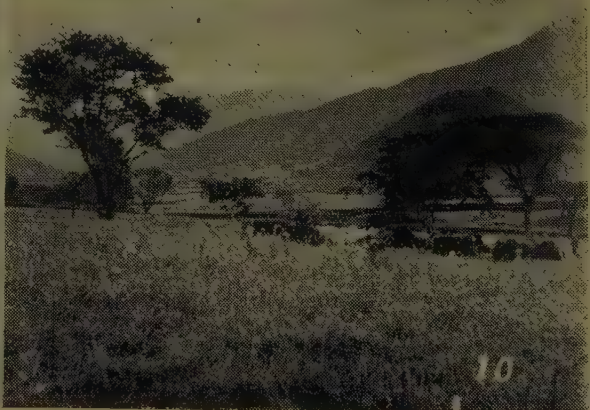
PHOTOGRAPH No. 8.—A plot grazed by cattle alone in goat v. cattle grazing experiment at Mpwapwa, June, 1944. This plot had good perennial grass cover in 1938, but has since not been weeded. Note absence of perennial grasses and baring of ground between bushes.



PHOTOGRAPH No. 9.—A plot browsed by goats alone in the goat v. cattle grazing experiment at Mpwapwa, June, 1944. This plot has a better perennial grass cover than it had in 1938, in spite of no weeding being done.

PHOTOGRAPH No. 10.—One of the Star grass paddocks at Mpwapwa, which are grazed on a rotational basis and weeded once a year. Seven years previously this land was under native cultivation. Note contrast with conditions shown in Photograph No. 6.





RECENT INVESTIGATIONS OF ANTESTIA SPECIES IN UGANDA

PART I

By T. H. C. Taylor

(*Received for publication on 5th July*, 1944)

A few years ago I wrote a general account of *Antestia* as a pest of coffee in Uganda, with special reference to the conditions prevailing in small, African-owned plots (Taylor, 1940). Since then much further work has been done, especially on the parasites of *Antestia*, but except for brief notes in the Annual Reports of the Department of Agriculture this later work has not been reported. My object throughout these investigations was to obtain a definite answer, negative or positive, to the question as to whether anything could be done to reduce the damage due to *Antestia* in small coffee plots. Before this work reached a satisfactory conclusion it became necessary (in 1942) to divert my attention to another problem which was considered to be of greater urgency, and I had then intended to resume and complete the *Antestia* investigations after the war. This is no longer possible because I am leaving Uganda shortly, and I am therefore writing an account of my work and conclusions to date (March, 1944) in the hope that it may be of use to my successors as a guide to the comparatively small amount of work which remains to be done.

This report is intended to supplement, not to replace, earlier accounts of *Antestia* in Uganda (Hargreaves, 1940, and Taylor, loc. cit.), which should be used for reference in conjunction with it. I propose to avoid repetition as far as possible and therefore to deal herein only with those aspects of the problem upon which recent work throws new light.

DISTRIBUTION OF *Antestia* SPP. IN UGANDA*

Six species of *Antestia* are known to occur in Uganda and all are represented in the insect collection at Kawanda. *A. faceta* Germ. and *A. lineaticollis* Stal. are the well known coffee species. *A. cincticollis* Schaum. is a comparatively rare species which has nevertheless been found in almost all districts, usually on composite flowers, and at altitudes varying from 3,000 ft. (near Lake George) to 7,500 ft. (on Ruwenzori); occasionally adults have been found on coffee, but although the true host plants are not known there seems no doubt that coffee is not one of them. *A. cincticollis* is important as a carrier of the parasite *Corioxenos* and will be referred to again hereafter in this connexion. A fourth species has been determined as "near *trivialis* Stal." and is represented in the collection by a single specimen obtained as an adult on coffee in Kyagwe. Two more species, neither of which has been specifically determined, are known, one from Kyagwe and the other from Kawanda; several adults of the latter were obtained on wild *Rubus*, but it is unsafe to assume that the species breeds on *Rubus*. These last three species might, on further investigation, prove to be widely distributed, like *cincticollis*, in which case they would acquire economic importance as probable hosts of some or all of the parasites which attack *faceta* and *lineaticollis*.

The accompanying map illustrates the distribution in Uganda, so far as it is known, of the two serious coffee pests, *A. faceta* and *A. lineaticollis*. They inhabit different types of country, but it is very difficult to define precisely their natural habitats. *A. faceta* is mainly a species of the eastern and northern parts of Uganda, and is to be regarded as a forest insect in the sense that it is indigenous in the neighbourhood of dense forest. The widespread cultivation of coffee, however, has extended its distribution and enabled it to flourish in areas in which it almost certainly is not indigenous, and this result has masked to some extent its status as a forest insect. *A. lineaticollis*, on the other hand, is confined to the south-west. In Uganda, except for a

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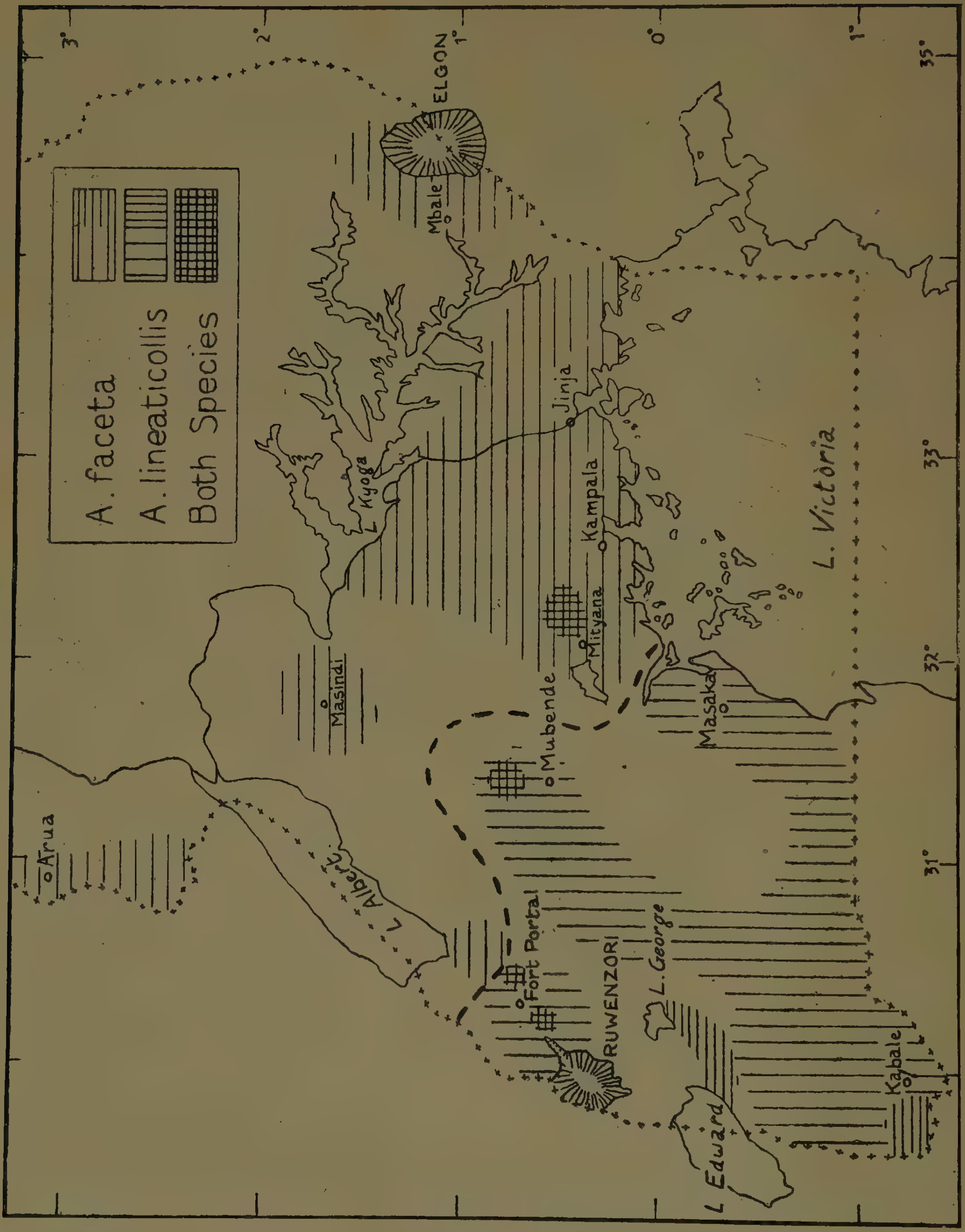
* On the accompanying map the names of districts and parts of districts are omitted because they would obscure the smaller shaded portions. In many cases the positions of areas referred to are sufficiently indicated in the text and in others the name of the principal township, shown on the map, is the same as that of the district concerned (Mubende and Masaka). The positions of the remaining areas are indicated in the following notes:—

Toro, Kigezi, Mengo, West Nile, and Bugishu are districts having their headquarters at Fort Portal, Kabale, Kampala, Arua, and Mbale, respectively. Ankole is a south-western district adjoining, and east of, Kigezi. Kyagwe is a part of Mengo lying between Kampala and Jinja; Bunyaruguru is a northern part of Ankole, near Lake George; and Bufumbira is the south-western part of Kigezi.



Distribution of *A. faceta* and *A. lineaticollis* in Uganda small area near Mityana, it does not occur east of Long. 32°, and its northern limit is Lat. 1°N. It appears to belong to a more open and drier type of country than *faceta*, and although in parts of certain districts (e.g. Toro and Masaka) it is plentiful in the neighbourhood of dense forest its distribution does not seem to be governed by forest as is that of *faceta*. Moreover, like *faceta*, it has spread with the cultivation of coffee to areas in which it is not indigenous. I regard the open, grassy, hilly country of Ankole, Kigezi, and parts of Toro as the typical habitat of *lineaticollis* in Uganda. The altitude range of the two species in Uganda is from about 4,000 ft. to about 7,000 ft.

The approximate dividing line between the *faceta* and *lineaticollis* country is shown as a broad dotted line on the map. It would be almost correct to shade all the country to the north and east of this line for *faceta* (to the Victoria Nile, Lake Kyoga and Mt. Elgon); and all the country to the south and west of it for *lineaticollis* (to the Uganda border, but not further in the west, and excepting the small faceta areas shown): but I have shaded only those areas in which I definitely know that *Antestia* occurs in many localities.

The two small *faceta* patches in the south-west corner of the map (which represent Bunyaruguru and Bufumbira) are not actually so isolated as they appear. It is true that they are not connected with the main area of occurrence of *faceta* in Uganda, but they are actually eastern extensions of a large expanse of *faceta* territory (how large, I do not know) in the Congo, adjoining Uganda. *A. faceta* is plentiful in the neighbourhood of Ruchuru in the Congo, and it probably extends northwards from there to and beyond Lake Edward.

In all probability the main *faceta* area should extend to include some localities near and to the north of Lake Kyoga. *A. faceta* has been found in the bush in Buruli, on the southern shore of this lake, but has never been found or searched for on its northern shore.

There are very few localities in Uganda in which both species occur together. I know of only four. This serves to emphasize the difference in habitat between the two species. The four localities known to me are shown on the map. Two of them may be attributable, I suggest, to the introduction of the one or the other species by human agency; thus, at Namutamba, near Mityana, *lineaticollis* is present and extends for a few mile northwards but not southwards, and this is *faceta* territory; similarly, *faceta* is present in *lineaticollis* territory at and around Kakumiro near Mubende. In Toro there is slight overlapping in two localities. Near (but not at) Rubona both species have been obtained together, and this part of Toro is otherwise occupied by *lineaticollis* only; but the country adjoining it to the east, which includes the crater lakes and the forest around them as well as western offshoots of Kibale Forest, probably contains *faceta* in the wild state. The two species also occur together at Kigarama in Toro (but not on the neighbouring estate Kiamara); this is not surprising since the junction of the known *faceta* and *lineaticollis* parts of Toro is not far away.

The only considerable area in Uganda in which coffee is extensively grown and both species of *Antestia* are completely absent is in the south of Busongora County of Toro, at the southern extremity of the Ruwenzori Range. I sprayed many *arabica* trees in many localities around Bwera and Kisunga and at different altitudes, in order to test them for *Antestia*, but I obtained none whatever. Also, the insects are quite unknown to the inhabitants. It might be argued that *Antestia* is probably present but maintained in a state of rarity by local factors not operating elsewhere in Uganda. I am certain, however, that this is not the case and that both species are absent not only in the coffee plots but also in the bush. There are, unfortunately, indications that *Antestia* is slowly spreading southwards via coffee plots on the eastern side of the mountain. Should either species reach south Busongora an excellent opportunity would be presented for testing the value of the parasites in a new environment.

The distribution of *Antestia* spp. in other African territories has been summarized by Kirkpatrick (1937).

HOST PLANTS OF *A. faceta* AND *A. lineaticollis*

The known host plants (i.e. plants on which breeding occurs) in Uganda are:—

A. faceta	*A. lineaticollis*
Canthium vulgare *Canthium golugence* *Psychotria nigropunctata* *Pavetta olivierana* *Tricalysia* sp. *Coffea canephora* ("robusta") *Coffea arabica*	*Pavetta* sp. ? *nitida* *Galiniera coffeoides* *Coffea canephora* ("robusta") *Coffea arabica*

Other plants on which adults only of *A. faceta* have been found feeding in considerable numbers and in circumstances which suggest that breeding occurs on them are *Vangueria apiculata, Rutidea* sp., and *Rytigynia* sp.

All of these plants belong to the Rubiaceae, and having searched for *Antestia* on a great variety of plants of other families without finding any nymphs (and very rarely finding any adults), I agree with Kirkpatrick (1937) that the host plants of *Antestia* are entirely confined to the Rubiaceae. Recent work in the Congo (Lefevre and Hendrickx, 1942) has shown that *Antestia* is unable to breed on any plant species (other than Rubiaceae) of the great variety tested, with the exception of *Jasminum abyssinicum* on which individuals were reared from egg to adult in the laboratory. There are many references in literature to the occurrence of a species of *Antestia* (*A. cruciata*) on Jasmine (and coffee) in India, but nowhere, so far as I can ascertain, is it stated whether the insect actually breeds on Jasmine. In Uganda, I have frequently examined wild jasmine (2 spp., including *abyssinicum*) for *Antestia,* but always with negative results. I conclude, in the absence of evidence to the contrary, that *Jasminum* rarely serves as a true host plant in the field and is of little importance in this connexion.

Although the host plants are restricted to Rubiaceae and include numerous genera within this family, there are several genera of Rubiaceae which appear never to be host plants in the field. I have little doubt, however, that *Antestia* could be reared on species of most of these in laboratory conditions. It is noteworthy that despite great attention paid to *Tarenna pavettoides, Heinsenia diervillioides* and *Oxyanthus* sp. ?*speciosus* (three wild host plants of the well known coffee pests, *Bixadus sierricola*), *Antestia* has never been observed on any of these. The fact that *Coffea arabica* is a major host plant while "robusta" coffee rarely serves as such shows that there are very definite gradations in suitability within the Rubiaceae.

The most important wild host plants of *A. faceta,* from the economic point of view, are almost certainly *Canthium* spp. and *Pavetta* spp., and in the case of *A. lineaticollis* I attach special importance to *Pavetta* and *Galiniera,* having regard to the different types of country which the two species of *Antestia* inhabit. At least one of these three plant genera is represented in almost all actual or potential coffee-growing areas. There are many very isolated coffee plots in Ankole and northern Kigezi, in all of which *lineaticollis* has apeared. At first sight, the presence of the insect in such localties seems surprising, especially in view of the barren nature and limited flora of the exposed grassy hills of that part of Uganda. Intimate acquaintance with those localities shows, however, that *Pavetta* sp. ?*nitida* is never far away. Sometimes it is at the bottom of a small valley and sometimes in an isolated clump of bushes on a hillside. In the case of *A. faceta,* the presence of the insect in almost every coffee plot in the areas in which it occurs is less remarkable, because *faceta* territory supports a very much more varied flora, especially of woody shrubs and trees. There is no possibility whatever of reducing the infestation on coffee by destruction of wild host plants. No such procedure is practicable under Uganda conditions. The importance of the wild plants lies only in the realization of their existence as sources of *Antestia* wherever coffee is or may be grown, and in the part they play in facilitating the survival and general distribution of certain of the parasites of *Antestia,* particularly those which attack the nymphs.

I have referred in earlier reports (1940, 1941) to "robusta" coffee as a host plant of both species of *Antestia.* My statements to the effect that both species definitely breed on "robusta" in the field appear to conflict with those of Hargreaves (1940, quoting earlier work) and Kirkpatrick (1937), both of whom found that in the laboratory nymphs cannot survive when provided with "robusta" berries. The explanation is that in special circumstances the tree as a whole, not merely its fruit, is a true host plant. Precisely what the special conditions are I do not know, but they are certainly associated with moisture and shade. The "robusta" trees in which I have found *Antestia* breeding plentifully far from arabica have always been large, old trees with much foliage, and partially sheltered and shaded by other larger trees. I conclude that *Coffea canephora* (robusta), no doubt like many other Rubiaceae, is normally unsuitable as a host plant, but should nevertheless be regarded as such, and that the planting of it in certain lower areas (which has been suggested) in order to form a protective barrier to prevent *Antestia* reaching *arabica* plots higher up is useless. That "robusta" coffee is not normally liable to severe damage by *Antestia* is certain and obvious.

I have never found *Antestia* on any of the wild coffees, which are nevertheless likely to be host plants. *C. eugenioides* is widely distributed in Uganda, though not common. *C. excelsa* and *C. spathicalyx* are exceedingly local.

THE PARASITES OF *Antestia* IN UGANDA

The primary parasites of *Antestia faceta* and *A. lineaticollis* in Uganda are listed below:—

Attacking the Eggs:—

(1) *Acroclisoides africanus* Fer. (Pteromalidae).

(2) *Anastatus antestiae* Fer. (Eupelmidae).

(3) *Hadronotus antestiae* Dodd. (Scelionidae).

(4) *Microphanurus mopsus* Nixon (Scelionidae).

(5) *Microphanurus seychellensis* Kieff. (Sceliondiae).

(6) *Microphanurus suranus* Nixon (Scelionidae).

(In addition to these six primary parasites, four secondary parasites have been obtained from *Antestia* eggs in Uganda; these are *Aprostocetus* sp. (Eulophidae), two spp. of *Pleurotropis* (Eulophidae), and *Baryconus* sp. (Scelionidae).)

Attacking the Nymphs:—

(7) *Aridelus (Helorimorpha) coffeae* Brues. (Braconidae).

(8) *Aridelus (Helorimorpha) taylori* Nixon. (Braconidae).

Attacking the Nymphs, but maturing in the Adults:—

(9) *Corioxenos antestiae* Blair. (Strepsiptera).

Attacking the Adults, and occasionally the Nymphs:—

(10) *Epineura rubens* Villen. (Tachinidae).

References to literature concerning these parasites are listed by Kirkpatrick (1937). Since 1937, two more papers which are important from the systematic point of view have appeared, one by Ferriere (1940) and one by Nixon (1941). It should be noted that the inclusion in my previous list (Taylor, 1940) of two Eupelmids is incorrect, the error being due to confusion in earlier literature in the names of the sexes and varieties of one species which is now known as *Anastatus antestiae*, Fer.

In the remaining sections of this report I propose to discuss the economic usefulness of these various parasites and to indicate what further work concerning them should, in my opinion, be undertaken.

EGG PARASITES

All of the six primary egg parasites, with the exception of *Hadronotus antestiae*, are present in all of the principal coffee-growing areas of Uganda (including Ankole and Kigezi), and one or more of them is present in every plot of every district. The most abundant and generally distributed are *M. seychellensis* and *Anastatus antestiae*. Several of them are known to attack the eggs of other Pentatomid bugs also, but except for *A. antestiae* (which has been obtained from Coreid eggs as well as those of Pentatomids), they appear to be restricted to Pentatomids. Their range of hosts, which includes certain very common and generally distributed genera such as *Agonoscelis* and *Cyclopelta*, accounts for their presence everywhere. In the case of *Anastatus antestiae* only, the survival and abundance of the species in any locality depends upon the presence of some host whose eggs are larger than those of *Antestia*, since *Antestia* eggs almost invariably produce males only of this parasite and larger eggs produce both sexes; I have on one occasion obtained a few females from *Antestia* eggs, but this is a very rare occurrence.

Hadronotus antestiae was one of the most common of the parasites of *Antestia* eggs prior to about 1928, at least in western Uganda. It is now one of the rarest, if not completely absent in most localities. I have collected *Antestia* eggs in representative localities in all coffee-growing districts for several years and have only once obtained it, and then only one specimen. This one came from an extremely isolated coffee plot in open grass country at Lugaga in South Ankole. This suggests that *Hadronotus antestiae* is a species of dry, open country and that its absence in most coffee plots and estates in recent years may be connected with the growing up of the coffee trees which may have resulted in conditions unfavourable to it. This explanation, however, seems scarcely adequate, and may possibly be contradicted by the circumstances in which the parasite occurs in Kenya (and with which I am not acquainted). It is possible that this species still occurs in other hosts in its former haunts, as I have not attempted to survey its alternative hosts; but if this were the case one would expect it to appear at least occasionally in coffee. The reason for its disappearance or rarity remains obscure.

The combined effect of the various egg parasites, with or without other parasites, is very great and very valuable. If they were not present *arabica* coffee could not be grown as an economic crop in Uganda, and that they are particularly valuable in small African-owned coffee plots, in which other parasites (except *Aridelus*) have difficulty in surviving. The presence of at least one species of egg parasite in every small plot is guaranteed by the existence of alternative hosts in the vegetation surrounding the plot. As a rule, two or more species of egg parasites occur together, and this ensures continuous destruction of *Antestia* eggs in all conditions throughout the year, since each parasite no doubt has its own host preferences and ecological requirements, which differ from those of the other species.

Since several species of these egg parasites occur together in all districts and most localities there is probably little to be gained by moving any of them from one area to another. The possibility of increasing their efficiency by collecting *Antestia* eggs in quantity, releasing the parasites which emerged from them in the same locality, and destroying the *Antestia* nymphs from the non-parasitized eggs, was considered and tested many years ago on large estates and found ineffective and impracticable. The reason for the failure of this method was, in all probability, that the number of egg batches collected was actually only a small proportion of the whole, and this, I fear, would always be the case. This method, even if it had been successful, is quite unsuitable for African growers. A third method, which appears satisfactory in small plots, especially if the plots are not clean-weeded, is to prune the trees at regular intervals in such a way as to make them more open and to expose all parts of them to light, air, and parasites. Unfortunately, most Africans are very unwilling even to prune their arabica coffee; but this reluctance has in itself served to emphasize the effect of pruning on the damage done by *Antestia*, because in Bugishu the plots which are properly pruned are conspicuous by their own scarcity as well as by the comparative scarcity of *Antestia*. Since pruning is likely to be increasingly recommended, if not enforced, for reasons other than *Antestia* control, I am hopeful that a general and considerable reduction in *Antestia* damage may eventually be brought about.

It is not clear precisely how "opening up" the trees causes a higher percentage of egg parasitism in small plots. It may be merely that the parasites can find the egg masses more easily, or that the changed microclimate within the trees is less favourable to *Antestia* without affecting the egg parasites, the population of which depends to a considerable extent upon other vegetation in and around the plots. Whatever the reason may be, the percentage parasitism is higher in plots in which all the trees are "open", and it is reasonable to assume that if all the plots in any neighbourhood were uniformly pruned periodically (preferably annually) the degree of control permanently exercised in each plot would be greater than at present. I have often been quite unable to find any non-parasitized eggs in suitably pruned plots, while in unpruned plots nearby parasitism rarely exceeds 50 per cent except at a late stage in a severe outbreak. Inability to find non-parasitized eggs does not mean 100 per cent parasitism, since the number of batches discovered is small, but it does mean at least 90 per cent.

There is some evidence to indicate that the effect of pruning on egg parasitism is less in large continuous areas of coffee (European estates or communal African-owned plantations) than in small isolated plots. The reason probably is that the influence of the fauna of surrounding vegetation is relatively negligible in large continuous areas of coffee. Additional contributory factors may be that large estates are usually shaded by trees; and that their very extent affects the climate within them, whether shade trees are planted or not. I do not regard the egg parasites concerned as forest insects, and I would expect any practice which causes an approach to forest conditions to be *relatively* unfavourable to them. Their normal hosts (in areas where there is no coffee and therefore little *Antestia*) probably include a great variety of Pentatomid species on mixed vegetation in fairly open country and rarely include *Antestia*. My recommendations for pruning as a means of encouraging egg parasites therefore apply to small African-owned plots (like the majority in Bugishu), not necessarily to large estates.

I have already made brief reference to weeds in coffee plots. From the point of view of control of *Antestia* by parasites they are of great importance, and will be referred to again hereafter. Here it may be noted that, in general, the percentage destruction of host individuals by a parasite increases with the density of the host population, and in the present instance the numerous Pentatomid eggs of species other than *Antestia* which are present on weeds are included equally with *Antestia* eggs in the host population. Thus the total host density in the presence of weeds is greater, and probably much greater, than the density of *Antestia* eggs alone, and the percentage parasitism correspondingly higher. Obviously, one cannot recommend a permanent, rank, uncontrolled growth of weeds in coffee plots. My point is that the converse of this condition—namely, complete and permanent clean-weeding—is very highly undesirable. An intermediate condition, such as a mixed growth of herbaceous weeds (other than grasses) in alternate interrows, with or without mulch in the remaining rows, is the ideal. Both this and pruning should fit in with general agricultural practice as advocated by agricultural officers, and the entomologist can assist greatly in spreading propaganda on these lines by undertaking periodical tours in the districts concerned and co-operating closely in the course of them with the district staffs. This has, in fact, become part of my own routine work in recent years, and although the lack of response on the part of many of the chiefs and peasants has been disappointing and obstacles have arisen in consequence of the war, the results obtained have at least sufficed to raise hopes for the future.

I have no actual proof in the form of hard figures that the principles which I have cited in explanation of the effects of pruning and weeds on egg parasites represent the true course of events. Statistical proof is impossible, and we can only quote observed results. Nevertheless, long familiarity with *Antestia* and much longer acquaintance with parasites in general leave no doubt whatever in my own mind that the explanations given are sound; but I do not rule out the possibility that there may be additional factors at work of which we have no indication at present.

With regard to future research work on egg parasites, there is little more than can usefully be done (from the economic point of view to which I have confined myself). I suggest, however, that an attempt should be made as opportunity offers to find out more about the alternative hosts of *Hadronotus antestiae* and the reasons for its disappearance from coffee. Such an investigation might throw much light on the ecology of the *Antestia* parasite complex as a whole; and the possibility of making some use of *H. antestiae* in Bugishu, which is to be regarded as an island area in which some insects which are absent could actually flourish (especially in the changed conditions provided by the widespread cultivation of coffee), should not be ruled out.

THE NYMPHAL PARASITES, *Aridelus* SPP.

The two species of *Aridelus* (*Helorimorpha* of some authors—*see* Nixon, 1941) are both widely distributed in Uganda. I have reared adults of *A. coffeae* in West Nile, Bugishu, and Mengo Districts, and *A. taylori* in West Nile and Bugishu, and by dissecting *Antestia* nymphs I have obtained *Aridelus* larvae (which are readily distinguished from the larvae of other parasites of *Antestia*) in almost all of the coffee-growing areas of the Protectorate except the south-west. Some of the many small samples of nymphs which I have dissected in various localities showed almost total parasitism, and I believe that such intense parasitism occurs from time to time in all localities. These two species are undoubtedly of very great importance in contributing to the total of natural control.

Both species often occur together in the same coffee plot, and one or other of them is present in almost every small plot as in every large estate. This very general distribution suggests that they attack other Pentatomids besides *Antestia*, but I have no direct evidence in support of this suggestion, probably only because I have not studied the nymphs of other species. *A. coffeae* is known to parasitize both *A. faceta* and *A. lineaticollis*. I have actually reared *A. taylori* only from *faceta*, but I have no doubt that it attacks *lineaticollis* also or that both species of *Aridelus* also attack all the other species of *Antestia* which occur in Uganda. I think it likely that *Aridelus rufus* Cameron, which has been reared from *Antestia* in Tanganyika, occurs in Uganda too, and that a more thorough study of these parasites of the nymphs would reveal its presence. I possess a specimen of *Aridelus* which is almost certainly *A. africana* Brues.; it was reared in Uganda from an adult of the Pentatomid *Piezodorus pallescens* Germ. which feeds on a variety of leguminous plants, and since three species of the genus are definitely known to parasitize *Antestia* it would not surprise me if *A. africana* also were found to do so.

The three species of *Aridelus* reared from *Antestia* all oviposit in young nymphs, and the mature larvae normally emerge from large nymphs and occasionally from adults. Only one parasite develops in each host. On emergence from the host the larva immediately proceeds to spin a white cocoon of very tough texture, from which the adult parasite emerges after a period varying from three to four weeks (Bugishu, Nov. 1938). For additional particulars concerning the habits and development of *Aridelus* reference should be made to the work of Kirkpatrick (1937). The genus *Aridelus* belongs to the same subfamily (Euphorinae) of the Braconidae as *Euphorus* which includes the important parasites of *Lygus*, and the habits of the two genera are very similar.

Further investigation of *Aridelus* spp. in Uganda, particularly in the field, is necessary and has for some time been part of my projected programme. They have been less thoroughly studied than any of the other parasites of *Antestia*, although they are the only true nymphal parasites and play an important part (between the egg parasites on the one hand and *Corioxenos* and *Epineura* on the other) in the sequence of parasitism. Like the egg parasites, but apparently unlike *Epineura*, they thrive in small plots of coffee as well as large areas, and this gives them additional importance. There is no evidence to indicate that they are affected in any way by pruning, but since the cocoons are probably formed in or on the soil I would expect ground treatment to be important, as it is in the case of *Epineura*. Future work should include periodic examination of *Antestia* nymph samples (say four times a year) from selected localities to ascertain the degree of fluctuation in percentage parasitism in known conditions and the species of *Aridelus* concerned; for the former purpose, dissection of part of the sample is essential and simple. Attention should also be paid to alternative hosts. I do not advocate, in this or other cases, a thorough survey of other hosts, but it is very desirable to obtain as opportunity occurs a general idea of the host range in order to interpret correctly observed differences in percentage parasitism and in *Antestia* incidence and abundance in different environments. I have never found Aridelus in Kigezi or Ankole. This is probably merely because I have not specially set out to study it, but the matter should be settled definitely, when opportunity offers, by dissection of series of nymph samples.

It seems desirable to point out that a record of a *Mesochorus* sp. parasitizing *Antestia* in the Congo (Lefevre and Hendrickx, 1942) is probably an error. I believe the genus *Mesochorus* (Ichneumonidae) is hyperparasitic, the hosts of many species being Braconidae. The parasite referred to may therefore have been a secondary parasite of *Antestia* via *Aridelus*.

Corioxenos antestiae BLAIR

This interesting and valuable parasite occurs in several districts of Uganda, but not in all. I have obtained it in West Nile, Toro, Ankole, and Kigezi. In Toro it is present in the county of Kyaka (and I therefore conclude that it is present in the adjacent part of Mubende District) and also in the small coffee area to the north of and including Fort Wavertree, near the south end of Lake Albert. In Ankole it is plentiful in the neighbourhood of Lwasamaire, but not throughout the district, and in Kigezi it is common in many localities in the north, but appears to be absent from the south. To state definitely that an insect such as *Corioxenos* is absent in any particular area is rash unless one has worked in that area for a considerable time and periodically for several years. It is easy to decide whether *Corioxenos* is present or absent in coffee plots by repeated sampling of the *Antestia* populations in the coffee trees, but there is strong evidence to indicate that where it is absent in coffee it is often present on other species of *Antestia* which do not frequent coffee and that several years must sometimes elapse before it becomes established in the coffee plots. On the other hand, if a large number of coffee plots in one area are all found on repeated examination to lack *Corioxenos* then it is safe to assume that the insect is actually absent in that area. My remarks concerning its distribution in Uganda are made with due caution and with these difficulties in mind.

On the whole this parasite belongs to what I regard as *lineaticollis* country; but it is not present in all parts of the territory in which *lineaticollis* occurs, and in one or two localities where it is found the species of *Antestia* occurring in coffee is *faceta*, not *lineaticollis*. *Corioxenos* is particularly plentiful in the type of country, represented by Lwasamaire in Ankole and Rukungiri in Kigezi, which consists mainly of steep, treeless hills covered with short grass in which flowering herbaceous plants, especially composites, abound. Certainly it is a species of the drier, non-forested, belts of Uganda, and I am convinced that it is absent in the Mabira Forest area of Kyagwe, throughout Bugishu (with the proviso made below), and in the Kibale Forest area of Toro (including the country, south-west of Fort Portal, which includes Buhesi, Rubona, and Kisomoro); the indications are that it does not occur anywhere in the Elephant-grass zone.

In December, 1940, I obtained two specimens of *A. faceta* parasitized by *Corioxenos* in a coffee plot above Bunambale in Bugishu, at an altitude of 7,000 ft. I have not included Bugishu (Mt. Elgon) in my list of districts in which *Corioxenos* occurs because there is strong evidence that this one instance is highly exceptional and abnormal. I know Bugishu particularly well and I have dissected very large numbers of *Antestia* in all parts of the district over a period of years without ever finding *Corioxenos* anywhere except in this one plot. Moreover, samples taken at the same time from numerous other plots in the neighbourhood of Bunambale contained no *Corioxenos*. The most likely explanation is that although the parasite is absent from the district as a whole, it occasionally occurs in certain localities near the Kenya border owing to the movement of individuals of one of its hosts from the very different country on the other (drier) side of the mountain. I have never found *Corioxenos* in large samples of *Antestia* collected at Bupoto and Magale, which are even nearer than Bunambale to the "dry side" of the mountain, but this does not disprove the hypothesis. The possible inference that this curious occurrence of the parasite at the highest limit of coffee-growing in Bugishu may mean that it is indigenous on some species of *Antestia* which inhabits the high mountain forests, may be dismissed because all the evidence from other districts shows that it is not a forest insect and because I have never obtained it in other localities at about 7,000 ft. in Bugishu.

Being a Strepsipteron, *Corioxenos* undoubtedly has a very small range of hosts. I agree with Kirkpatrick (loc. sit.) that it is "a specific parasite of the genus *Antestia*". In Uganda it flourishes as a parasite of *A. faceta*, *A. lineaticollis*, and *A. cincticollis*, and I have little doubt that it attacks the other undetermined species of *Antestia* also. I regard *A. cincticollis* as an important factor in ensuring the presence of *Corioxenos* near most of the coffee plots, even the very isolated ones, in the exposed hilly country of Ankole and Kigezi. This species of *Antestia*, though relatively uncommon, is frequently observed on composite flowers on the grassy hills, and is heavily parasitized by *Corioxenos*.

Kirkpatrick reared this parasite experimentally in *Antestia trivialis* Stal., but failed to rear it in *A. falsa* Schout. In the case of *trivialis*, however, he found that the parasite did not develop so readily in it as in *lineaticollis*, and from some experiments and observations on *faceta* he concluded tentatively that *faceta* also is less suitable as a host than *lineaticollis*. He remarks that the facts which he records "indicate that *Corioxenos* would be unlikely to become established in *faceta*, where this is the only species of *Antestia* present". These findings, while wholly justified by the evidence available to Kirkpatrick, need some modification in view of more recent observations in Uganda. In a part of Toro (Kahuna and other estates) where *faceta* is the only species of *Antestia* present, *Corioxenos* became abundant and was one of the major factors in suppressing a severe outbreak. I have not conducted laboratory tests as Kirkpatrick did, but my field observations show that both *faceta* and *lineaticollis*, in addition to *cincticollis*, are entirely satisfactory as hosts for this parasite, at least under the conditions in which they occur naturally in Uganda. It therefore seems likely that every species of *Antestia* is suitable as a host, but there may be different degrees of suitability among the species in any given set of ecological conditions.

Some years ago, before any detailed observations on *Corioxenos* had been made, I held the view that this parasite could never be of appreciable economic value because of the relatively precarious methods by which the young larvae (triungulins) of all Strepsiptera gain access to their hosts. It is now evident that this view is false, or rather that it is only true when *Antestia* is present in comparatively small numbers. All parasites depend, for the degree of parasitism which they can attain, upon the density of the host population; but whereas (in the case of the parasites of *Antestia*) *Aridelus* and *Epineura* can attain a high percentage of parasitism in an *Antestia* population of, say, 10 per large coffee bush, *Corioxenos* is usually almost negligible in such a population. As soon as its host becomes really abundant, however, *Corioxenos* becomes as important as the other parasites as a destructive factor, and its principal economic role undoubtedly is the shortening of the duration of the periods of abundance of its host rather than the prevention of outbreaks. I should perhaps add that by "really abundant" I refer to a population of the order of 50 (nymphs and adults) per large bush, but numerical data in work of this kind are liable to be dangerously misleading because so many factors (notably actual size of bush, density of foliage, amount of crop, and pruning system adopted) confuse the issue.

It is obvious that although *Corioxenos* is visible externally on adults (under the wings) and therefore adults are conveniently used for sampling, the population of nymphs, not adults, is the crux of the matter because the triungulins enter nymphs only. The great variations in percentage parasitism which occur from time to time are due to a considerable extent to fluctuations in the nymphal population, not the total *Antestia* population. In hot, dry weather, for example, and if the trees are bearing little or no crop, little breeding of *Antestia* occurs. The population may be high, owing to breeding some months previously, but it consists almost entirely of adults in these circumstances and is therefore useless to *Corioxenos*.

Notley (1941), writing of *Corioxenos* in Tanganyika, remarks that: "At the Coffee Research Station (Lyamungu), where the coffee is almost entirely unshaded, *Corioxenos* has been of little importance; in the other two districts its importance has been considerable". The "other two districts" are Uru and Arusha, and the coffee plots in them in which the observations were made were heavily shaded. My own observations in Uganda lead me to conclude that *Corioxenus* thrives best in unshaded plots. These apparently conflicting views probably do not actually conflict at all. The effect of shade, not only on *Antestia* and its parasites but also on the coffee trees themselves, may well vary greatly in different climates and habitats. In any case it would be rash to assume from the scanty evidence at present available that shade is primarily and directly responsible for the differences observed.

Two attempts to establish *Corioxenos* in localities where it was absent previously have been made in Uganda and both have been successful to the extent that the parasite has become established, at least temporarily. I regard both attempts as highly experimental and I consider it important that the future activities of the parasite in both cases should be carefully watched periodically so that information may be obtained on the degree of control exercised, the rate and extent of control and the desirability of spreading the parasite artificially.

The first experiment was conducted in Toro District. 664 adults of *A. faceta* were collected at Kahuna in September, 1940, and 120 of these were examined and dissected for analysis of parasitism. The sample of 120 contained three individuals attacked by *Corioxenos* and 30 by *Epineura*. Thus, the remaining 524 *Antestia* individuals included about 13 parasitized by *Corioxenos* and about 130 by *Epineura*. All of the 524 were liberated in the small communal plot at Butukuru, near Rubona, where *A. lineaticollis* was abundant and *faceta* entirely absent. I am quite certain that neither of these two parasites was present at or anywhere near Butukuru previously. Despite the very small number of *Corioxenos* introduced, this parasite became established, but this is not so remarkable as it appears since Kirkpatrick has shown that each female produces a very large number of triungulins, sometimes over 3,000. Incidentally, *Epineura* failed to become established. Subsequent visits to Butukuru showed the following parasitism by *Corioxenos*:—April, 1941 (7 months after liberation), 17 per cent; September, 1941, 33 per cent; July, 1942, 28 per cent. It is very probable that the percentage parasitism rose much higher between September, 1941, and July, 1942. In the latter month the *Antestia* population (*lineaticollis* only; *faceta*, though introduced, did not become established) was very much lower that it had been during 1940 or 1941. I cannot state definitely that the reduction in population was due to *Corioxenos*, but I believe that it was.

In July, 1942, I used this plot at Butukuru as a source of *Corioxenos* for introduction into Bugishu, and the number of *Antestia* removed from it for this and other purposes was so large, relative to the total population, that the normal course of events must have been affected. Therefore, I decided to make no further observations at Butukuru for some time; but the normal balance between parasite and host has no doubt been restored by now, and observations should be resumed as soon as opportunity offers. The most important conclusion to be drawn from the Butukuru experiment, as far as it has gone, is that *Corioxenos* can be established from a very small number of adult individuals. As regards the ability of the parasite to spread, we have little evidence so far; but in July, 1942, I took a large sample of *Antestia* from all parts of Rubona estate, which is not more than half-a-mile from the Butukuru plot, and found no *Corioxenos* in it. Further observations at Rubona are desirable. The spread of the parasite must obviously depend largely upon the movements of its host, since the female never leaves the host. Triungulin larvae may attach themselves to various insects which visit coffee trees and may thus be transported long distances, but the chance of the species becoming established in a new locality in this way is exceedingly remote. It would, however, be a very simple (if tedious) matter to distribute the parasite (as parasitized hosts) from various centres such as Butukuru in which it has become well established.

The second experiment was conducted in Bugishu. 317 adults and 131 nymphs of *lineaticollis* were collected at Butukuru and taken to Bugishu at the end of July, 1942. A sample examined at Butukuru showed that about 30 per cent of adults and nymphs were parasitized, and it follows that about 100 parasitized adults and 40 parasitized nymphs were included in the Bugishu consignment. On arrival in Bugishu the percentage parasitism in nymphs was probably much higher than 30 per cent because all the *Antestia* were crowded into three cages and many of the adult *Corioxenos* were discharging triungulins during the journey, and at least one triungulin attached itself to almost every nymph. The Bugishu consignment was divided into two lots: One lot consisted of 200 adults and 90 nymphs, and was liberated at Sipi; the other consisted of 131 adults (several nymphs having become adult during the journey) and about 20 nymphs, and was liberated at Bumasobo. (The precise localities are well known to the local chiefs and Agricultural Instructors.) At Sipi the conditions at the time were unfavourable owing to unusual scarcity of *Antestia*. At Bumasobo, all stages of *Antestia* (*faceta* only in Bugishu) were common.

Unfortunately, six months of very exceptionally dry weather followed the liberation of the parasites, and in consequence breeding of *Antestia* almost ceased at Sipi, where the drought was extreme. The trees ceased to produce crop and the foliage became scanty. By March, 1943, when I next visited both localities, nymphs were exceedingly scarce at Sipi, and since *Corioxenos* cannot breed without nymphs it is not surprising that I failed to recover it. I am not prepared to state definitely that it failed to establish itself, but I think this very likely. Future visits will settle this point. At Bumasobo, on the other hand, the drought had been much less severe and I recovered the parasite readily in *faceta* in March. Since I was certain, from examination of large samples of *Antestia* from both localities in previous years, that *Corioxenos* was not present until I liberated it, and since it was liberated in *lineaticollis*, the recovery of it in *faceta* was conclusive proof that breeding had occurred. *A. lineaticollis* was still present in March, in the form of nymphs and adults, and had obviously temporarily established itself from the specimens which I introduced. (This raises a most interesting point which I shall discuss in a later section of this report.) Both species of *Antestia* were common in March, and the trees were producing much crop; and although the percentage parasitism, after so short a period, was low and negligible the conditions seemed suitable for rapid multiplication of the parasite. I have not visited Bugishu again since then and therefore cannot report later developments. If it is considered in future that *Corioxenos* is likely to flourish permanently at Bumasobo, the distribution of it to other localities in Bugishu should be undertaken.

(*To be continued*)

There can be few among us who will not support Viscount Bledisloe's plea to press very strongly upon His Majesty's Government that the time has come when there ought to be research—research not merely conducted in watertight compartments affecting on the one hand the health of plants, on the other the health of animals, and in the third place the health of human beings and some relation between the soil and all of them, but comparative research on the important problem of the interrelation between the morbid conditions of soil, plant, animal and human beings.

DR. HUGH NICOLL quoted in *Tropical Agriculture.*

We knew here, even before the belief attracted a wider support and conviction, that a modern nation, as certainly as a well-organized modern industry, depends for success upon generous and far-seeing expenditure on scientific research and on the recruitment of first-rate ability to its service, and risks failure and disaster by parsimony and a narrow vision of its responsibilities in these directions.

SIR HENRY DALE in his presidential address to the Royal Society at its 281st Anniversary Meeting.

Without courage there can be no other virtue. **Sir Walter Scott.**

THE VALUE OF ANIMAL PROTEINS, ESPECIALLY SEPARATED MILK, IN PIG FEEDING

By **M. H. French, M.A., Ph.D., Dip.Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory**

(*Received for publication on 29th November*, 1944)

During the war, protein concentrates of animal origin, such as meat or blood meal, have been in short supply and there have not been enough to meet the demands of the pig industry. Even before the war, there was a tendency amongst farmers to use as little meat meal as possible in feeding pigs because of the expense and high transport charges involved. In fact, many pigs were never fed meat meal in spite of the fact that it is now fairly widely appreciated that pigs grow quicker and make more economical gains if their ration contains protein of animal origin. Dairying is becoming increasingly important but, since the sale of fresh milk is confined largely to urban areas, the major part of the dairy industry must be concerned with the production of butterfat. This means that large amounts of separated milk could be made available for pig feeding. Separated milk has a well-deserved reputation as a pig food, particularly in the feeding of young pigs, weaners and baconers and many of the world's most successful pig industries have developed alongside, and are dove-tailed into, dairy enterprises. By this means a by-product of the latter is converted into an important raw material for the bacon industry.

The following experiments were carried out to show (*a*) the value of protein concentrates of animal origin, and (*b*) the value of separated milk in replacing these concentrates in the feeding of bacon pigs.

Before describing the experimental work, it is perhaps advisable to explain and justify the practice at Mpwapwa of using only small numbers of animals, since one criticism of past work here has been that too few animals have been used. There are two ways of investigating live stock feeding problems; one is to use large numbers of animals under normal farming conditions and to consider the average results from each group, the other method is to use much smaller numbers under carefully controlled conditions when each animal is fed and considered individually. The large-scale experiments are much more costly to run and, with the limited amount of money available, they are avoided at Mpwapwa. They are costly because with large numbers of animals much more labour, food and capital (in the form of buildings) are involved. The departmental policy is to breed and distribute breeding pigs to farmers and if large numbers were used for feeding trials either the distribution policy would have to be curtailed or much larger breeding units would have to be maintained. Mpwapwa has, in the past, been situated a long way from a bacon factory and, if the experimental animals were transported to the factory over bad roads, considerable bruising and deterioration in the quality of the carcass would result. With only a few pigs fed individually the carcasses can be disposed of locally whilst the labour, food, housing and breeding expenses are kept to a minimum. Always, of course, animals from different litters are used to avoid errors due to one litter doing better than another, but from each litter involved enough pigs were taken to enable one to be subjected to each of the different feeding treatments under investigation.

On this question of group feeding versus individual feeding of pigs, it is interesting to quite from the work of Woodman, Evans, Callow and Wishart [1] who investigated this matter statistically. They observed that "clearly the group-feeding technique lacks the sensitiveness of the individual-feeding method" and that "The group-feeding trial is thus the link between practical feeding and scientific experimentation and may indeed be regarded as a verification under practical conditions of the significance of the results of the individual-feeding trial. By itself, when the expected differences to be investigated are small, the group-feeding technique may be of very limited value. When carried out side-by-side with the individual-feeding trial, however, it may . . . constitute an important confirmation". These workers found, when examining different pig rations, that owing to the large number of possible variants involved the group system gave differences which were not large enough to be statistically significant but that the individual feeding methods gave differences which were statistically significant and which could be correlated with the differences in feeding.

There is therefore considerable justification for using the individual-feeding technique and, when, as at Mpwapwa, the money and numbers of pigs available are strictly limited, it seems to be the only method to be adopted.

In the present study two different rations were used and their compositions are shown in Table I, but it is worth recording that ration H (containing 5 per cent meat meal) had proved itself very satisfactory in the past and of the rations without animal protein ration N was the best that had been tested previously at Mpwapwa.

TABLE I

COMPOSITIONS OF THE PIG RATIONS

	Ration H	Ration N
	Per cent	*Per cent*
Maize Meal	52	57
Rice Polishings	20	10
Meat Meal	5	—
Cowpeas	20	10
Cake	—	20
Lime	2	2
Salt	1	1

These two rations had approrimately the same starch-equivalent values but the ration containing no animal protein had 17.5 per cent digestible protein compared with only 14.3 per cent in the meat meal ration. There is thus no deficiency in the quantity of protein supplied by ration N as compared with mixture H though the proteins in the latter naturally will have the higher biological value.

The individual-feeding technique was used to compare rations H and N as well as the same mixtures when supplemented with one pint of separated milk daily. In addition, the opportunity was taken to feed four pigs in the normal farm method or group system and to compare their average rates of growth and efficiencies of food conversion with similar animals fed by the individual-feeding method. Table II summarizes the results obtained when the pigs were fed to 200–210 lb. liveweight and given a small quantity of green lucerne daily.

As would be expected, ration H, containing 5 per cent meat meal, enabled pigs to be fed to bacon weight in a shorter time and at less cost in food per lb. of liveweight increase than on ration N which contained a higher digestible protein content but no protein of animal origin. Similarly, the feeding of separated milk not only increased the feeding values of both rations H and N but, because it stimulated appetites and improved the digestibilities of the rations, increased the average rates of liveweight increase and enabled the fattening period to be shortened. In this connexion, it is interesting to recall that previous work on the digestibility of pig foods had shown [2] that the addition of separated milk to a ration increased the digestibility and feeding value of the meal mixture. In the present trials the separated milk had only a slightly greater effect on the pigs on ration N than on those on ration H (with meat) and the value of N + milk was still less than that of H + milk.

TABLE II

SUMMARY OF FEEDING TRIALS

Pig No.	Ration	Meal consumed per lb. liveweight increase	Average daily rate of liveweight increase	Number of days to reach bacon weight
3 ..	H (containing meat)	2·97	1·40	122
8 ..		2·89	1·35	131
21 ..		2·89	1·29	132
Average		2·92	1·35	128
4 ..	N (without meat)	3·24	1·27	128
7 ..		4·09	0·91	181
13 ..		3·38	1·06	174
Average		3·60	1·08	161
*5 ..	H with separated milk	2·72	1·56	109
10 ..		2·31	1·74	96
11 ..		2·32	1·63	104
19 ..		2·49	1·57	120
Average		2·46	1·62	107
*2 ..	N with separated milk	2·70	1·54	114
9 ..		3·10	1·17	152
Average		2·90	1·35	133
15 .. 16 .. 17 .. 18 ..	Group fed on H and separated milk	2·70	1·20	155

*These pigs received two pints instead of one pint of separated milk daily.

It is also interesting to observe that, with ration H supplemented with separated milk, the average figures for four animals fed by the individual-feeding technique were much better than recorded for four similar pigs fed by the group-feeding system. The food consumed per lb. of liveweight increase was more in the group-feeding system and the rate of gain in liveweight considerably less and even below the rate of gain for ration N with separated milk in the individual feeding tests.

The quantity of meal required to produce 1 lb. liveweight increase in the individually fed pigs showed the following interesting relationships:—

(*a*) Pigs on ration H (5 per cent meat meal) consumed 81.1 per cent of the meal required by the pigs on ration N (no animal protein).

(*b*) Pigs on ration N and separated milk consumed 80.6 per cent of the meal required by pigs on ration N.

(*c*) Pigs on ration H and separated milk consumed 84.2 per cent of the meal required by pigs on ration H.

The addition of separated milk to pig rations can be expected to reduce meal consumption per lb. liveweight gain by 15–20 per cent according to whether or not foods containing proteins of animal origin are included in the meal mixtures. The addition of separated milk to a ration containing no animal protein reduced the food consumption to the level recorded for a good ration containing 5 per cent meat meal. The use of separated milk with foodstuffs of local origin can therefore eliminate the necessity for purchasing expensive animal protein concentrates and when these concentrates are in short supply, allow pigs to be fattened economically with the minimum consumption of other meal mixtures. There is thus every reason why more use should be made of separated milk in the feeding of pigs because, apart from its great value as a source of protein of high biological value, its stimulating effect on appetite and its ability to allow animals to make more economical use of the meal mixtures fed, it is a valuable source of the lime which is so often lacking in pig rations and it also contains important quantities of vitamins.

In order to see what effect these rations had on the quality of the carcass the data in Table III was collected.

The results show that in length the gilts averaged 30.27 in. and hogs 31.10 in. For thickness of fat over the shoulders and loins the gilts averaged respectively 4.55 cm. and 2.24 cm. whilst the figures for the hogs were 4.88 cm. and 2.43 cm. In belly thickness the gilts averaged 2.97 cm. and the hogs 2.81 cm. There was thus not a great deal of difference between the carcasses from gilts and those from hogs, though the gilts which were slightly shorter, less fat on the back and had slightly thicker bellies, a fact probably connected with the mammary gland development.

The average carcass measurements show that the carcasses from each group of individually fed pigs would have been degraded because of deficient belly thickness whereas the group-fed pigs would not have been penalized for this fault. In other respects the carcasses would all have graded Class I Grade A on the British grading system. This deficient belly-thickness has been commented on in a previous article [3] and appears to be a character of the Mpwapwa strains of pigs.

The pigs on ration N had the longest carcasses but this is possibly because they took longer to fatten. The carcasses of this group were the least finished as the wider ratio of shoulder to loin fat and the thin layers of fat

TABLE III

CARCASS MEASUREMENTS

Pig No. and Sex	Ration	Length	Shoulder fat thickness	Loin fat thickness	Mean rump fat thickness	Belly thickness	Shoulder muscle thickness	Loin muscle length	Loin muscle depth	Flank thickness
		Inches	*c.m.*	*c.m.*	*c.m.*	*c.m.*	*c.m.*	*c.m.*	*c.m.*	*c.m.*
3 (Female)	H	30·25	4·60	2·40	2·45	3·40	8·95	9·10	4·75	2·50
8 (Female)	H	29·88	4·10	2·35	2·30	2·78	9·65	9·00	4·65	2·30
21 (Male)..	H	32·75	5·00	2·40	2·38	2·55	9·50	9·20	4·90	2·40
Average ..		30·96	4·42	2·38	2·38	2·91	9·37	9·10	4·77	2·40
4 (Male)..	N	30·63	4·85	2·40	2·27	2·42	8·80	9·25	3·60	2·60
7 (Female)	N	31·50	4·55	1·80	2·05	3·00	9·20	9·50	4·55	2·70
13 (Male)..	N	31·50	4·55	2·20	2·27	3·00	9·10	8·95	4·40	2·20
Average ..		31·21	4·65	2·13	2·20	2·81	9·03	9·23	4·18	2·50
5 (Male)..	H with separated milk	29·25	5·10	2·45	2·65	2·67	9·50	9·55	4·50	2·55
11 (Male)..	ditto	29·75	5·00	2·80	3·13	2·77	9·00	9·35	4·50	2·20
19 (Male)..	ditto	32·75	4·80	2·35	2·48	3·13	9·55	9·25	4·80	2·80
Average ..		30·58	4·97	2·53	2·75	2·86	9·35	9·38	4·60	2·52
Group 3 ..	Group fed on H with separated milk	30·44	4·48	2·40	2·50	3·29	9·28	9·30	4·65	2·60
2 (Female)	N with separated milk	29·50	4·80	2·60	2·50	3·07	9·45	9·35	4·50	2·20
9 (Female)	ditto	30·25	4·70	2·05	2·32	2·60	8·90	8·35	4·20	2·25
Average ..		29·87	4·75	2·32	2·28	2·83	9·17	8·85	4·35	2·22

on the loins and rump indicate. The thicker loin and rump fats indicate that the carcasses from pigs on ration H were better finished than those on ration N and that, in each case, the feeding of separated milk improved the finish. The thickness of the muscles show that the pigs receiving ration H or separated milk had better developed muscular systems than the pigs on ration N.

The distribution of weight in the carcasses of these pigs were measured and are shown in Table IV.

The data obtained suggest that the distribution of the carcass weight between the various portions is not affected by the feeding so much as is the finish of the carcass. Ration N appears to have yielded carcasses which contained lower proportions of hind-quarters and sides but higher proportions of secondary offals than the other mixtures. The smaller muscular development may be responsible for the lighter sides and hams whilst the greater quantity of internal fat and the heavier heads and feet increased the proportions of the secondary offals.

In order to see what effect the rations had on the quality of the fat in the carcasses, iodine values were determined on samples of back fat from each pig and the following average values were found: on ration N, 68.2 on ration H 60.5; on ration N and separated milk, 62.4; on ration H and separated milk, 59.7.

Ration N gave carcasses with a softer back fat than ration H and the feeding of separated milk caused a harder fat to be deposited. The production of soft fat in the carcasses of pigs fed ration N is not due solely to the influence of the ration because these pigs fattened more slowly and slow fattening will produce a softer carcass fat irrespective of the ration fed. This also partly explains the hardening effect of the separated milk because the milk-fed pigs always fattened more quickly.

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Table IV

Distribution of Weight in Pig Carcasses

Pig No. and Sex	Ration	Live weight	Carcass	Carcass	Secondary offals	Secondary offals	Hind-quarters	Hind-quarters	Fore-quarters	Fore-quarters	Weight of sides	
		Lb.	*Lb.*	%	*Lb.*	%	*Lb.*	%	*Lb.*	%	*Lb.*	%
3 (Female)	H ..	205·9	166·3	80·7	38·95	23·44	35·75	21·5	39·6	23·8	52·0	31·3
8 (Female)	H ..	209·6	170·0	81·1	38·80	22·8	38·10	22·4	41·5	24·4	51·6	30·4
21 (Male)..	H ..	201·0	160·75	80·0	32·45	20·2	37·90	23·6	41·9	26·1	48·5	30·2
Average ..		—	—	80·6	—	22·1	—	22·5	—	24·8	—	30·6
4 (Male)..	N ..	204·0	157·0	77·0	41·20	26·3	31·20	19·9	37·6	23·9	47·0	29·9
7 (Female)	N ..	203·5	169·0	83·0	40·40	23·9	37·70	22·3	42·9	25·4	48·0	28·4
13 (Male)..	N ..	212·25	168·3	79·3	40·40	23·3	34·60	20·6	44·1	26·2	49·2	29·9
Average ..		—	—	79·8	—	24·5	—	20·9	—	25·5	—	29·4
5 (Male)..	H with separated milk	205·6	165·5	80·5	36·90	22·3	35·60	21·5	38·6	23·3	54·4	32·9
11 (Male)..	ditto	206·0	164·8	80·0	38·70	23·5	34·00	20·6	36·6	22·2	55·5	33·7
19 (Male)..	ditto	225·5	179·65	79·7	36·65	20·4	42·50	23·7	44·5	24·7	56·0	31·2
Average ..		—	—	80·1	—	22·1	—	21·9	—	23·4	—	32·6
2 (Female)	N with separated milk	206·1	162·2	78·7	40·40	24·9	37·50	23·1	38·4	23·7	45·9	28·3
9 (Female)	ditto	209·0	183·0	87·5	42·25	23·1	40·75	22·2	44·6	24·4	54·4	30·3
Average ..		—	—	83·1	—	24·0	—	22·6	—	24·1	—	29·3

SPRAYING SMALL AREAS AGAINST POTATO BLIGHT

By R. M. Nattrass, B.Sc. Agric., Ph.D. (Lond.), D.I.C., Senior Plant Pathologist, Kenya

Mention has already been made (Nattrass, 1944) of the possible use of A.R.P. stirrup pumps for spraying small plots of potatoes. These pumps are equipped with a nozzle which throws a jet of liquid or a coarse spray. A trial showed that with the aid of these pumps, small plots could rapidly be covered with little movement about the crop being necessary. The jet throwing the fine spray will enable all the plants to be sprayed within six yards of the nozzle. By turning the nozzle from "spray" to "jet", a further two or three yards can be covered, as the jet some distance from the nozzle breaks up into coarse drops. It is thus possible, from one position of the bucket, to cover an area of some 500–600 square yards with the standard 18-foot hose.*

It has, in the past, generally been maintained that for efficient control of blight, the spray fluid must be put on as a fine misty spray and that both the upper and lower leaf surfaces must be covered. With high pressure sprayers, and a suitable nozzle, it is possible to envelop the plants in a mist cloud so that all parts may receive some of the mist particles. With the usual bucket or stirrup pump covering the undersides of the leaves is an ideal which the writer has never been able to achieve.

Experiments by Marsh and Martin, 1941, and 1942, have shown that good control of blight can be obtained by sprinkling the plants with a fungicide from a watering can fitted with a fine rose. It is obviously impossible with this method to apply the fungicide to the undersurfaces of the leaves. It appears, therefore, that the complete cover of both surfaces, formerly advocated, is not necessary. Assuming that wherever drops or films of moisture tend to collect, there will the blight spores be also and as, as has been demonstrated, Wain and Wilkinson (1943) minute amounts of copper become soluble in water on the leaf, the fungicidal action of the deposit will tend to inhibit spore germination even when the spores are not in actual contact with it.

By means of the A.R.P. pump, a somewhat similar watering-can effect is produced but with the drops having some lateral velocity so that some of the liquid reaches the stems and part of the underside of some leaves. By moving the nozzle in a wide arc, the operator can cover a considerable area more rapidly than by walking between the rows with an outfit delivering the misty type of spray.

A better cover, approximating that from a misty spray can be obtained if the plants are sprayed while still wet with dew. The impact of drops of the fungicide from a watering can or jet nozzle on the leaf surface, breaks the surface tension film of the dew drops and causes a mixture of the fungicide and dew to spread over the leaf in an even film. It is not suggested that this is the ideal way to spray potatoes; it uses a good deal of liquid and some drip is inevitable, but it does produce an excellent cover which will give good control. The best method to apply the liquid can be arrived at by trial. Walking between the rows swinging the watering can at arm's length, is one way. With the jet-throwing pump, the nozzle must be kept moving rapidly over the crop. All that is required is to supply some fungicide on each leaf, the dew will see to the spreading of it. When dry, the deposit is as evenly spread as when applied by the more conventional type of nozzle. The method allows of a very rapid spraying of small plots. A bucketful can be applied with the jet pump and 300–400 square yards covered in a few minutes.

As the fungicide is somewhat diluted by the dew, a stronger solution should be used. With Burgundy Mixture, a strength of not less than 2 per cent is recommended.

It is possible that "dew spraying" may be of value on a larger scale with high pressure sprayers, and the use of the spray gun type of nozzle.

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* Readers may query this figure which is arrived at as follows: Hose 18 feet fine spray 6 yards. Jet 8 yards. Radius of circle 14 yards. Area $= 3.14 \times 14^2 = 615$ sq. yd.

BOVINE BRUCELLOSIS: THE USE OF LIVE VACCINES IN THE CONTROL OF THE DISEASE

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Hitherto in Tanganyika Territory, and probably to a certain extent in other East African territories, the importance of many other animal diseases, in particular rinderpest, has tended to obscure that of contagious bovine abortion.

This disease is caused by a bacterium of the *Brucella* group, and the species most commonly affecting cattle is *Br. abortus*. A description of the condition, compiled by the Veterinary Department of Kenya, was given in Vol. VIII, No. 2 pp. 92 to 94 [6] of this Journal and so no details will be given here of the symptoms, course, and diagnosis of the disease. It must be remembered, however, that the disease is insidious in onset and of great economic significance to the farmer, and also that it has serious relationships with public health.

The insidious nature of brucellosis is such that the disease may not be recognised in a herd of cattle until it is well established, unless resort is had to the serum agglutination test. The economic significance manifests itself in loss of progeny by abortion, loss of milk, decrease in general level of health, the incidence of breeding abnormalities and even sterility.

The importance of the public health aspect of this disease will readily be understood when it is realized that all forms of Brucella fever in human beings are of a very unpleasant nature, that the disease sometimes proves fatal, and that infected animals are either directly or indirectly the source of infection in human beings. The disease is known to occur frequently among human beings in East Africa [2] [14] and is almost certainly of much higher incidence than is represented by the number of actually diagnosed cases.

It is obvious therefore, that the importance of Bovine Brucellosis must be recognized in East Africa, as it has, perforce, been recognized in other parts of the world, notably the United States of America and Great Britain.

METHODS OF ERADICATION

There are three main lines of attack on this disease, and eradication, or even control, can only be expected if one of these, or a combination of them, is followed. They are:—

(1) Serum agglutination testing with segregation of non-reactors and freshly weaned calves;

(2) Serum agglutination testing with slaughter of all reactors;

(3) Immunization by vaccination.

Of these methods, the first and second present great difficulties in any part of the world and almost insuperable ones in East Africa. Lack of accommodation and the expense of maintaining dual establishments are corollaries of the first method and great economic loss due to the slaughter of grade or high milk-producing native cows is consequent upon the second.

For the farmer in East Africa therefore, there remains the third method, viz. vaccination. It is with this subject that this paper is mainly concerned.

VACCINES

In recent years, a considerable amount of research has been done on the application of vaccines to the problem of Bovine Brucellosis. Attempts to produce resistance or immunity with dead or inactivated vaccines have been many [7] but all have proved fruitless. However, great strides have been made in the production of live vaccines, prepared from specially attenuated strains of *Brucella abortus*. Many of these have been produced and tried, but two in particular have received the greatest measure of attention and recognition.

The first of these is Strain 19 (S. 19), isolated in America and subjected to extensive field trials in that country. It has, for many years, been used in "Calfhood vaccination" programmes of Brucella control and has now been adopted by the Ministry of Agriculture and Fisheries in Great Britain for official use. The second is Strain 45 [20], developed by McEwen, A. E. [8] [9], in England and now also adopted for official use by the Ministry of Agriculture and Fisheries.

By the courtesy of the Director of the Veterinary Laboratory of the Ministry of Agriculture and Fisheries, at Weybridge, the author received dried cultures of both these strains at the Mpwapwa Laboratory and having nursed them out, has carried out several experiments with them on dairy cattle in Tanganyika. Sufficient information has been forthcoming to permit of a considered opinion on the possible value of vaccination against bovine contagious abortion in East Africa.

THE USE OF STRAIN 19

S. 19 is a "smooth" strain of *Br. abortus*, and causes the production of agglutinins in vaccinated animals. The use of the vaccine is therefore accompanied by inability to use the serum agglutination test as a method of picking out infected animals, as there is no means of differentiating between an agglutination reaction due to the vaccine strain and one due to actual virulent infection. However, in the United States of America, the use of this vaccine has been restricted officially to calves between the ages of four and eight months.

If used on calves only, the agglutinins induced by vaccination gradually disappear from the blood as the animal grows older so that in not less than 90 per cent of cases the animal is negative to the agglutination test by the time it produces its first calf.

A relationship between the age at which the animal is vaccinated, and the length of time required for the disappearance of the agglutinins from the blood has been found to exist, viz: the younger the animal when vaccinated, the sooner a negative result is obtained to the agglutination test [11]. However, it is stated that the age at which an animal is vaccinated has no effect upon the results of subsequent parturitions, but some authors have recorded cases in which vaccination of pregnant cows has led to abortions, which were apparently caused by the vaccine strain itself [5].

STRAIN 45 (20)

Strain 45 (2) is a "rough" strain and as such, does not stimulate the production of agglutinins and so its use does not invalidate the serum-agglutination test. Early experimental work on this strain shows that it is promising but as yet it has not been subjected to as extensive trials in this country as has S. 19.

THE MPWAPWA TESTS

In Mpwapwa the animals used in the experiments have been drawn from two main herds; one a native Zebu herd, built up by selection on milk production and improved recently by the use of an Indian Zebu (Sindi) bull, and the other, a grade herd, consisting of Ayrshire-Zebu crosses and now being degraded by the use of an Indian Zebu (Sahiwal) bull. Before these experiments were begun, both herds had shown positive reactors of the serum agglutination test, and several abortions had occurred.

The experiments were planned to give information on the following points:—

(1) The effect of the vaccines on female bovines in various stages of pregnancy, at various ages, and in the non-pregnant state.

(2) The development of agglutinins due to vaccination with S. 19, and the rate of their disappearance from the serum of the vaccinated animal.

(3) The immunity or protection produced by the use of the two live vaccines (*a*) from the point of view of the individual animal; (*b*) having in mind the eradication of the active disease from any particular herd.

Details of those of the above experiments which have been completed, are not given here, as they are in preparation for publication under the titles: "An experimental study of the application of live vaccines to the control of bovine contagious abortion in dairy herds" and "A protection test for Brucella abortion antibodies, in the serum of a vaccinated bovine".

CONSIDERATION OF A PROGRAMME OF ERADICATION BY VACCINAL METHODS

It is now possible, from a survey of the work done on these vaccines, together with experience gained while conducting the above experiments, to suggest a plan of attack upon bovine contagious abortion in a dairy herd in this type of country under the conditions of farming imposed by the environment. At present our knowledge of, and experience with, S. 19 as a vaccinal agent are fuller than those concerning 45 (20) and so in this short account, S. 19 will take first place. Although it must be remembered that if the value of 45 (20) as an immunizing agent in cattle be adequately established, it is most probable that it will supersede S. 19 in the scope of its use.

The farmer confronted with bovine contagious abortion on his farm may therefore consider one of the following two main methods of eradication:—

A—The building up of a clean herd by—

(1) the segregation of reactors involving the use of separate buildings and land, the removal of calves from their dams at weaning and their segregation with the "clean" herd, and the continued application of the serum agglutination test to the "clean" herd at frequent intervals (say every three months) with the removal of reactors after every test, until a one hundred per cent negative result has been obtained over several successive tests;

(2) the elimination of reactors by slaughter, also involving frequent testing and elimination as indicated in (1) above.

B—Vaccination with a live vaccine.

For reasons stated earlier in this paper, the first two of these policies will not be considered here, and consideration will be confined to the third, viz. vaccination.

If the Strain 19 vaccine is to be used, then treatment may be confined to young animals and the policy of "calfhood vaccination" followed. This is the method which has been used in America extensively and has met with a large measure of success. It is felt, however, that the potentialities of the vaccine are not fully exploited by confining its use to four to eight month old calves, and that a much more vigorous attack on the disease may be made by vaccinating adult cattle as well as young.

Observations made in the above-mentioned experiments, and also the writings of other workers [1], [3], [4], [5], [11] and [12] on the subject, point to the following facts:—

(*a*) S. 19 vaccine *does* confer a good resistance to the disease.

(*b*) The vaccine may be used on pregnant cows and heifers in all stages of pregnancy causing neither abortion nor untoward symptoms other than a brief temperature reaction.

(*c*) When given to cows in milk, it causes no marked diminution in milk yield.

(*d*) The vaccine organism does not appear to be excreted by the vaccinated animal, except in a few cases, and in those cases there is no evidence to show that it has gained in virulence or pathogenic propensities, nor is it capable of establishing itself on the precincts as a pathogen.

(*e*) The S. 19 vaccine strain is not transmissible by contact from vaccinated to non-vaccinated animals.

A SUGGESTED PROGRAMME USING STRAIN 19

The writer feels confident, therefore, in using the S. 19 vaccine on bovines of all ages from four months upwards, and suggests that the attempt at eradication of Bovine Brucellosis from a farm may be undertaken along the following lines.

All the bovines should be submitted to the serum-agglutination test and negative reactors should be vaccinated. Positive reactors, i.e. animals already infected, may be left in the herd as they are unlikely to abort more than once or twice and thereafter will be immune. It is advisable to exclude from vaccination any animals more than five months pregnant. The writer has himself vaccinated cows without untoward result, even in the eighth and ninth months of pregnancy, but for general use it may be safer to exclude the animals in more advanced pregnancy than five months especially as it should not cause much inconvenience to vaccinate these after parturition and before their next service.

It must be remembered that an animal, although giving a negative result to the serum-agglutination test, may be incubating the disease and vaccination of such an animal will have no effect, good or bad, on the course of the disease. A few days after vaccination, agglutinins appear in the blood of the treated animals and so all will react positively to the serum-agglutination test. At this stage then, the test is no longer applicable to the herd.

All cattle subsequently brought onto the farm from outside must be tested and then vaccinated.

From now onwards, the herd must be kept under careful observation for abortions and steps should be taken to see that aborted foetuses, membranes and their concomitant discharges are removed and burned and, as far as is possible, are not allowed to come into contact with other animals. This is necessary, as, although the vaccinated animals will have developed a resistance, or immunity, it is only relative, and while being sufficient to protect against a reasonably light density of infection, will not necessarily prevent a super-infection from breaking through the preventive barriers [5] [13]. Good hygienic measures, however, will be sufficient to prevent the occurrence of such a super-infection.

From this point onwards, until it can be assumed with reasonable justification that the disease has been eradicated from the farm, all calves should be vaccinated as they reach the ages between four and eight months.

In the vaccinated stock the agglutinins will gradually diminish in the blood until eventually they will reach the stage at which the animals may be considered as negative to the agglutination test. Period tests at intervals of about six to nine months will be necessary to determine this and it will be found that the negative state is reached sooner in the animals which were young when vaccinated than those which received the vaccine as adults.

When the majority of the originally vaccinated animals have reached this stage, the vaccination of calves with S. 19 vaccine may be discontinued but henceforth all new cattle brought onto the farm from elsewhere, will have to be held in quarantine, undergoing two serum-agglutination tests before being admitted to the herd. These two tests should be separated by an interval of one to two months.

THE MAINTENANCE OF THE "CLEAN" HERD

From now onwards, the herd may be considered as "clean" if it is subjected to the serum-agglutination test periodically (six to nine month intervals) without these tests showing the incidence of new positive reactions. Theoretically, the herd should henceforth remain free of bovine contagious abortion, if all the precautions mentioned above are taken, the main possible source of fresh infection being cattle (and to a certain extent pigs and horses) introduced from outside the farm. However, infection may be reintroduced in other ways, especially if strict attention is not paid to hygiene and it may be advisable to continue vaccination of the herd, but with 45 (20) vaccine. This will not cause the production of agglutinins and so will not invalidate the serum-agglutination test.

Vaccine 45 (20) will also be of value to the farmer on whose farm the serum-agglutination test has revealed no positive reactors. The use of this vaccine, together with periodical testing, should enable him to keep the disease away from his cattle.

The plan of action to be adopted will, however, depend on several considerations, the mist important of which is the density of infection, and so each farm should be considered on its merits. These should be summed up in consultation with the Veterinary Officer of the district in which the farm is situated so that the most satisfactory plan may be devised and put into operation.

Both the vaccines referred to above are in preparation at the Veterinary Research Laboratory, Mpwapwa, Tanganyika Territory.

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DERRIS AGRONOMY: AN ANNOTATED BIBLIOGRAPHY AND A CRITICAL REVIEW

PART III

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Cebu has under cultivation 600 ha. mainly of a native derris, var. Pilipogon, "supposed to be a strain of *D. elliptica*". Analyses vary very widely up to 40.3 per cent ether extract and 9.45 per cent rotenone. Suggestion that plants grown on lime-rich soils have more rotenone than others.

*Finkelstein, A., 1936.—Derriswurzel und Rotenon. *Pflanzenbau* 10: 271. (*Cit.* Gehlsen, 1936.)

Frappa, C., 1937.—Les plantes à rotenone. Leur interet à Madagascar comme insecticide. *Bull. Econ. Madagascar* [N.S. No.] 9: 61-71.
Incidental reference to *Derris* spp., of which only *D. polyphylla* and *D. uliginosa* native. Possibilities as cover crops and interplanted in hevea, kapok and palms.

G——, 1931.—Derris und die insektizide Wirkung des Rotenons. *Tropenpflz.* 34: 163-166.
Agronomic data derived from Georgi and Curtler (1929).

Garnett, C. B., 1936.—Derris root. *E. Afr. Agric. J.* 2 (2): 111-113.
General account mainly of Malayan practice.

Gater, B. A. R., 1925 a.—Notes on miscellaneous insects in 1924. *Malay Agric. J.* 13 (6): 160-167.
Anomala pallida on derris.

— 1925 b.—Annual Report of the Entomological Division for 1924, *Malay. Agric. J.* 13 (7): 220-226.
Many lepidopterous caterpillars on derris leaves.

— 1925 c.—Investigations on "Tuba". *Malay. Agric. J.* 8 (10): 312-329. Also long summary (French) in *Rev. Trop. Agric. Bot. Appl.* 6: 175-177. Experiments on the insecticidal value of Malayan fish-poisons and list of pests of both growing and stored derris.

— 1926.—A preliminary list of food-plants of some Malayan insects. *Dept. Agric. Straits Setts. and F.M.S. Bull.* 38.
Pp. 43-44 give leaf, root and flower-eating insects of derris.

Gehlsen, C. A., 1936.—Derris (Tubawurzel). *Tropenpfl.* 39: 345-352.
A general account.

Georgi, C. D. V., 1929.—Variations in the amount of ether extract of Tuba Root (*Derris malaccensis* Prain). *Malay. Agric. J.* 17: 361-363.

— 1936.—Division of Chemistry. Annual report for the year 1935. *Dept. Agric. Straits Setts. and F.M.S. Gen. Ser.* 24: 15-21.
High variation in ether extract and rotenone between individual plants.

— 1937 a.—(Half-yearly reports July-December 1936; January-June 1937.) *Bull. Imp. Inst.* 35: 220-221, 492-494.
Changi 3 the best. Experiments to ascertain how "toxic content is influenced by change of environment" (more fully reported Georgi, Grieg and G.L.T., 1936).

— 1937 b.—A new method of harvesting, drying and sampling derris root. *Malay. Agric. J.* 25: 425-429.
Translated into Dutch in *Bergcult.* 11: 1675-1677.

— 1939 a.—The outlook for Malayan derris in the United States of America. *Malay. Agric. J.* 27: 3-14.
Results of a visit to U.S.A. Conclusion is against exporting powdered derris because of necessity for expensive, water-cooled, sealed mills.

— 1939 b.—Marketing aspects of derris and of its chief competitor, cube root. *E. Afr. Agric. J.* 5 (3): 176-185.
A reprint of Georgi (1939a) under a different title.

— 1940.—The outlook for derris. *Malay. Agric. J.* 28: 358-366.
D. malaccensis sold on ether extract, *D. elliptica* on rotenone. Importance of thoroughly random sampling before export is stressed. The *D. elliptica,* Sarawak creeping, averaging 6 per cent rotenone and 21 per cent ether extract, best for market, being preferred to Changi 3, 11 per cent and 25 per cent.

— (Also in Annual Reports Straits Setts. and F.M.S. 1931 +)

Georgi, C. D. V. and Curtler, E. A., 1929.—The periodic harvesting of Tuba root (*Derris elliptica* Benth.). *Malay. Agric. J.* 17 (9): 326-334.
Best age for harvesting, taking account of both yield and ether extract, 25 months. (Tables of yields per acre, proportions of coarse and fine root, moisture and ether at various ages.)

Georgi, C. D. V., Greig, J. L., Gunn Lay Teik, 1936.—Varietal and manurial trials with Derris. *Malay. Agric J.* 24 (6): 268-281.

Includes analyses of component parts of plants for plant nutrients and calculations of amounts removed from soil. Manurial trials not statistically significant and summarized in a misleading manner.

Georgi, C. D. V. and Gunn Lay Teik, 1932.—The rotenone content of Malayan Tuba root. *Malay. Agric. J.* 20: 498-507.

— 1933.—The valuation of Tuba root. *Dept. Agric. Straits Setts. and F.M.S. Sci. Ser.* 12.

— 1936.—Notes on the preparation of derris root for export, together with a suggested method of evaluation. *Malay. Agric. J.* 24: 489-502. Supplementary note on evaluation *ibid.* 25: 23 (1937).

— 1938.—Further selection experiments with *Derris malaccensis. Malay. Agric. J.* 26: 4-17.

— 1939 a.—Variation in toxic content of roots of *Derris malaccensis* var. *sarawakensis* with increase in age of plants. *Malay. Agric. J.* 27: 134-140.

Decrease in toxic content after 23 months.

— 1939 b.—Preliminary results of analysis of clonal types of derris under field conditions. *Malay. Agric. J.* 27: 302-331.

D. elliptica, Sarawak creeping, produces more root than *D. malaccensis* var. *sarawakensis* and increases in toxic content up to 34 months. Comparative data on other points for these two forms.

Georgi, C. D. V., and Gunn Lay Teik, 1940.—Further experiments with selected plants of *Derris elliptica* Changi No. 3. *Malay. Agric. J.* 28: 44-68.

Within a clone weight of root varies widely at all ages and 6 ft. by 4 ft. spacing does not necessarily give more root per plant than 3 ft. by 3 ft. spacing. Both rotenone and ether extract content vary widely within a clone. Rotenone content decreases after the age of 21 months. Rotenone averages about 45 per cent of ether extract, regardless of age or spacing.

Georgi, C. D. V., Lambourne, J., and Gunn Lay Teik, 1936.—Preliminary selection experiments with derris. *Malay. Agric. J.* 24: 374-389.

Georgi, C. D. V., Lambourne, J., and Gunn Lay Teik, 1937.—Variations in toxicity of some races of *Derris elliptica. Malay. Agric. J.* 25: 187-200.

Georgi, C. D. V., Lucy, A. B., and Gunn Lay Teik, 1939.—Manurial trials with derris. *Malay. Agric. J.* 27: 222-233.

Manures increased the yield of *D. malaccensis* var. *sarawakensis* but not of *D. elliptica*. Sarawak creeping; manures affected the toxic content of neither. Harvesting fine root of the *D. elliptica* doubtfully economic.

*Ghose, T. P., 1942.—A note on *Derris* and other rotenone bearing vegetable insecticides, their occurrence and possibilities of cultivation in India. *For. Leafl. Dehra Dun* 20. Pp. 9.

Derris ferruginea regarded as "sufficiently rich for preparation of insecticides" (*Plant Brdg. Abst.* 13: 107).

Glover, J., 1938.—A note on the rooting of *Derris* cuttings by a root-promoting substance. *E. Afr. Agric. J.* 4 (1): 72.

Beta-indole-acetic acid stimulated root production.

Greenstreet, V. R., 1930.—Division of Chemistry. Annual report for 1929. *Dept. Agric. Straits Setts. and F.M.S. Gen. Ser.* 3: 14-21.

D. elliptica and *D. malaccensis* (Erect Sarawak) best harvested at 23 months.

Greshoff, M., 1890.—Eerste verslag van het onderzoek naar de plantenstoffen van Ned. Indië. *Med. 's Lands Plantentuin,* 7: 12-20.

— 1893.—Beschrijving der giftige en bedwelmende planten bij de vischvangst in gebruik. *Med. 's Lands Plantentuin,* 10: 58, 68-70.

— 1898.—Tweede verslag van het onderzoek naar de plantenstoffen van Ned. Indië. *Med 's Lands Plantentuin* 25: 49-52.

— 1900.—Beschrijving der giftige en bedwelmende planten bij de vischvangst in gebruik. 2. *Med. 's Lands Plantentuin* 29: 51, 60-61, 174-175.

— 1913.—Beschrijving der giftige en bedwelmende planten bij de vischvangst in gebruik. 3 (supplement). *Med. Dept. Landb.,* 17: 72-74.

Grist, D. H., 1926.—Marketing of derris (tuba root). *Malay. Agric. J.* 14: 79-80.

Bulk of supplies derived from native growers in Borneo. Selection essential to enable plantation produce to compete.

— 1935.—Derris (Tuba root). *Malay. Agric. J.* 23: 477-482. Reprinted in *Trop. Agric. (Ceylon)* 86: 28-32. Also as Chap. 16 of *An outline of Malayan agriculture*: *Malay. Pl. Manual* 2, 1936. Also long summary (French) in *Rev. Trop. Agric. Bot. Appl.* 16: 230-231.

Guillaume, A., and Hervé, G., 1939.—L' appréciation de la valeur insecticide des plantes roténonées d'après le dosage de la roténone. *Rev. Bot. Appl. Agric. Trop.* 19: 552-564.

Discussion of methods of determining rotenone in commercial samples. Final selection the blue colorimetric method and the methoxyl group method.

Gunther, F. A., and Turrell, F. M., 1942.—A preliminary report of a critical examination of the roots of *Derris elliptica. J. Econ. Entom.* 35 (6): 941.

Localization of rotenone, starch and tannin; nature of resin bodies: possible importance of the saponins.

H.——de, 1940.—Derris II. *Bergcult.* 14: 553-554. Based on Georgi and Teik (1940) on Changi 3. (Derris I is the item under Sl——.)

Haller, H. L., Goodhue, L. D., Jones, W. A., 1942.—Constituents of derris and other rotenone-bearing plants. *Chem. Rev.* 30: 33-48.

Hansford, C. G., 1939.—Report of the Senior Plant Pathologist. *Rep. Dept. Agric. Uganda 1937-38* Part 2: 20-25.

Diplodia and *Fusarium* on diseased cuttings of *D. elliptica.*

Henderson, M. R., 1934.—The sources of "tuba" in the Malay Peninsula. *Malay. Agric. J.* 22: 125-130 + pl. 1.

Changi No. 3 first distinguished.

Heubel, G. A., 1938.—Beknopt overzicht van de ondernemingscultures in het Rayon Zuid-Sumatra gedurende 1937. (Short review of plantation crops . . .) *Bergcult.* 12: 678-689.

Selection by the colorimetric method being carried out on estates (*see* Meijer 1936).

— 1939.—Beknopt overzicht van de ondernemingscultures in het Rayon Zuid-Sumatra gedurende 1938. *Bergcult.* 13: 768-782.

Possibilities of interplanting derris in young rubber.

Heusden, W. C. van, 1937.—Beknopt overzicht van de ondernemingscultures in het rayon Zuid-Sumatra gedurende 1936. *Bergcult.* 11: 713-719.

Rigidoporus microporus on *D. elliptica*. *Coptosoma* and Hesperidae damaged young plants.

Heyn, A. N. J., 1938.—Du nombre de chromosomes chez quelques végétaux en cultures aux Indes Néerlandaises (*Coffea, Ceiba, Derris* et *Palaquim*). *Ann. Jard. Bot. Buitenzorg* 48: 103-120.

D. elliptica vars. have 25, *D. malaccensis* 22.

Higbee, E. C., 1943.—Rotenone production in the Amazon Valley. *Foreign Commerce Wkly.* 12 (4): 8-9.

H(ill), A. G., 1940.—Derris or tuba root: A note on yield and cost of production in East Africa. *E. Afr. Agric. J.* 5 (5): 362-363.

Cost Sh. 886 for 1,443 lb. (air-dry *D. elliptica*) at 30-36 months.

Holland, T. H., 1932.—The cultivation of derris for the manufacture of insecticides. *Trop. Agric. Ceylon* 79: 126-132.

Experience in Ceylon, with both *D. elliptica* and *D. malaccensis*.

Holman, H. J., 1940.—*A survey of insecticide materials of vegetable origin*. Impl. Inst. London. Pp. 155 incl. bibliog. 372 titles.

pp. 34-76 mainly devoted to derris. Growth of trade (to 1939), methods, producer countries and countries that have experimented are all dealt with. Brazil, Madagascar, Congo and Puerto Rico are the only countries not in the British Empire and not in Japanese occupation that seem to have experimented. Of these Madagascar negative. Especially valuable are comparative performances and botanical characters of the varieties that have attracted attention in Malaya.

*Hooker, J. D., 1878.—Report on the progress and condition of the Royal Botanic Gardens at Kew, 1877. Pp. 53.

Reports *D. elliptica* cultivated as insecticide at Singapore.

Huitema, W. K., 1938.—Selectie en landbouwkundig onderzoek bij Derris. (Selection and agronomic investigation in derris.) *Bergcult.* 12: 1035-1041.

Includes notes on diseases, a programme of agronomic investigation and some preliminary results.

(India).—*Forest research in India and Burma* 1933/34 +

Data on local *Derris* spp. and trials with *D. elliptica* in Assam.

Ippisch, F., 1940.—Raiz de derris y otras plantas insecticidos utiles e importantes para su cultivo en Guatemala. *Rev. Agric. Guatemala* 17: 320-322.

Introduction of *D. elliptica* (var. not specified) from the Philippines. Grown among coffee and bananas at 2,500 ft.

*Ishigai, K., 1937.—(Booklet on derris in Japanese.) Includes statement that various organic manures do not affect toxicity (Sievers, 1940).

*(Java).—*Verslag over het jaar 1938 van Het Algemeen Landbouw Syndicaat.*

*Jochems, S. C. J., 1926.—"Akar Toeba". *Ind. Cult.* (*Teysmannia*) 11 (24): 742-745.

— 1928.—Akar Toeba (*Derris elliptica*), het bestrijdingsmiddel van de Tabaksluis (*Myzus persicae*) in Deli. *Meded. Deli Proefst. Medan Sumatra* (2) 58. Pp. 61 + fig. 4.

Contains a bibliography of 58 titles. Chap. 2 deals with botany and culture of *D. elliptica*.

*Jones, H. A., 1933.—Notes on the occurrence of rotenone in species of *Derris* and *Lonchocarpus*. *J. Washington Acad. Sci.* 23 (11): 493-496.

No rotenone in leaves of *D. elliptica* and *D. uliginosa*, none in stems of former and 1 per cent in stems of latter (cf. *Biol. Abst.* 9: 1600).

Jung, K., 1938.—Pflanzliche Insektizide. *Tropenpflz.* 41: 431-443.

General account covers derris.

(Kenya).—*Department of Agriculture Annual Report, 1938.*

*Kojo, K., 1936.—On the rooting of derris cutting by his maturity [*sic*]. *Formosan Agric. Rev.* No. 353L: 41-44.

In Japanese with title in "English" (*Bibliog. Trop. Agric. for* 1936).

Koolhaas, D. R., 1934.—Derris root as a Netherlands India export product. *Econ. Bull. Neth. Ind.* 1 (3). Abst. in *Malaya. Agric. J.* 22: 236-238.

*— 1935.—Het drogen van derris-wortels. *Bergcult.* 9 (28): 625-627.

— 1938.—Eigenschappen van wortels van verschillende Derris-soorten. (Peculiarities of the roots of different derris varieties.) *Bergcult.* 12: 1045-1053.

Evaluation of derris roots, with details of rotenone, ether extract, and components of latter, for various clones of *D. elliptica* and *D. malaccensis*. Relation of rotenone content to root thickness.

*Krishna, S., and Ghose, T. P., 1936.—Occurrence of *Derris elliptica* in India. *Curr. Sci.* 4: 857-858.

*— 1938.— *Derris ferruginea* Benth. from Assam. *Curr. Sci.* 6: 22.

Corrects identification in preceding reference.

Krukoff, B. A., and Smith, A. C., 1937. Rotenone-yielding plants of South America. *Amer. J. Bot.* 24: 573-587.

Includes *Derris amazonica.*

*Laan, P. A. van der, 1936.—De localisatie van rotenon in derriswortels. *Pharm. Wkbl.* 73: 313-318.

Rotenone is "localized in parenchyma and pith cells present in both the wood and the bark" (*Brit. Chem. Abst. A* 1936: 533).

Laan, P. A. van der, 1940.—Dierkundige Afdeeling. *Meded. Deli Proefst.* (3) 7: 52-59.

Craniotectus pest of derris.

L(apiney), E., 1931.—Le derris et les propriétés insecticides du rotenon. *Agron. Colon.* 20: 46-47.

A summary of G——, 1931.

Legros, J., 1937.—Cultivation of Derris in the Far East. *Internat. Rev. Trop. Agric. 1937*: 1T-12T. Also long summary (French) *Rev. Bot. Appl. Agric. Trop.* 17: 540-543.

A summary for Malaya, Borneo, Philippines, Dutch Indies, on Malayan and Philippine published sources and a little unpublished for Borneo and Dutch Indies.

Lever, R. J. A. W., 1938.—Derris in Melanesia. *Fiji Agric. J.* 9 (2): 25.

*Llanes, R. M., 1940.—Morphological and microchemical studies of *Derris tubli* root from the Philippines. *Univ. Philipp. Nat. Appl. Sci. Bull.* 7 (4): 349-374.

"Rotenone abundant in the wood parenchyma and pith ray cells of the wood but less so in the cortical and pith ray cells of the bark" (*Exper. Sta. Rec.* 85: 322, 1944).

Maas, J. G. J. A., 1935.—De cultuur van derris-wortel (akar toeba). Soorten en cultuurformen van derris. *Bergcult.* 9: 1059-1062, 1103-1110, 1139-1151, 1179-1187, 1213-1217, 1248-1258.

Part 3, available at Amani in translation, deals with botany and high-yielding strains. Remainder gives an account of cultivation and uses. Bibliog. 275 titles.

*Maheu, J., 1925.—Les tuba parasiticides. *Bull. Sci. Pharm.* 1925 Nos. 3-5.

Contains anatomical details. References as quoted by Russell (1937).

(Malaya).—*Department of Agriculture Straits Settlements and Federated Malay States Annual Report*, 1925 +

For 1925-1928 in *Malay Agric. J.* 14-27. Thereafter in bulletins *Gen Ser.*, divided into (*a*) *Reports of Field Branch;* (*b*) *Technical Reports* (*Reports of Research . . . Branches*).

Marsh, T. D., 1939.—(Half-yearly report July-December 1938) *Bull. Imp. Inst.* 37: 201.

Attempt begun to hand-pollinate high-toxicity *D. elliptica* Changi 3 with high-yielding *D. elliptica* Sarawak Creeping.

Marshall, G. K. A., 1935.—New injurious Curculionidae (Col.) from Malaya. *Bull. Ent. Res.* 26 (4): 565-569.

Includes *Corigetus corbetii* on derris.

Martin, J. T., 1940.—The problem of the evaluation of rotenone-containing plants. V. The relative toxicities of different species of derris. *Ann. Appl. Biol.* 27: 274-294.

McIndoo, N. E., Sievers, A. F., and Abbott, W. S., 1919.—Derris as an insecticide. *J. Agric. Res.* 17: 177-200.

After testing six spp. (not including *D. malaccensis*) *D. elliptica* and *D. uliginosa* reported as satisfactory.

Meijer, T. M., 1936.—Eenvoudige colorimetrische methode om ongeveer het extractgehalte van derriswortel te bepalen. (Simple colorimetric method of estimating extract content of derris root.) *Bergcult.* 10: 1169-1170 and 1286.

— 1938.—Eenige eigenschappen van derriswortel. *Bergcult.* 12: 1562-1563.

Effect of temperature on content of rotenone and extract (with special reference to heat used in artificial drying).

Miller, N. C. E., 1930 a.—A major pest of *Derris; Neolepta biplagiata. Malay. Agric. J.* 18: 541-544.

Leaf-eating beetle.

— 1930 b.—Division of Entomology. Annual report for 1929. *Dept. Agric. Straits Setts. and F.M.S. Gen. Ser.* 3: 50-61.

Includes pests of derris plants.

— 1934 a.—Coleopterous pests of stored derris in Malaya. *Dept. Agric. Straits Setts. and F.M.S. Sci. Ser.* 14. Pp. 34.

— 1934 b.—Correction. [*Neolepta biplagiata* Jacoby should be *Craniotectus corbetii* Laboissière.] *Malay Agric. J.* 22: 367-368.

— 1934 c.—Control of insect pests in stored derris. *Malay. Agric. J.* 22: 367-368.

M(ilsum), J. N., 1924.—The flowering of tuba, *Derris elliptica* Benth. *Malay. Agric. J.* 12: 16.

Recorded as a rarity.

Milsum, J. N., 1932.—Seeding of *Derris elliptica. Malay. Agric. J.* 20 (11): 582 + pl. 1.

— 1936.—Derris cultivation in Perak. *Malay. Agric. J.* 24: 370-392.

D. malaccensis by Chinese.

— 1937.—Half-yearly report July-December, 1936. *Bull. Imp. Inst.* 35: 221.

Changi 3 unusually free-rooting: 100 per cent cuttings often take.

— 1938.—*Derris uliginosa. Malay. Agric. J.* 26: 18-19.

Toxicity too low to be of commercial value.

— (Also in annual technical reports Dept. Agric. Straits Setts. and F.M.S., 1929 +.)

Milsum, J. N., and Georgi, C. D. V., 1937.—Derris cultivation in Malaya. *Malay. Agric. J.* 25: 239-245.

A general account. Evidence for the superiority of Changi 3. System mentioned by which only laterals are harvested and tap left to grow.

Moore, R. H., 1937.—In *Puerto Rico Agr. Exper. Sta. Report* 1936 +.

— 1943.—Derris culture in Puerto Rico. *Puerto Rico Exper. Sta. Mayaguez Circ.* 24. Pp. 17.

Moore, R. H., and Jones, M. A., 1942-1943.—Physiology and agronomy of rotenone crops. *Puerto Rico Agr. Exper. Sta. Report* 1941, 15-17; 1942, 8-10.

Norris, F. M.—(In annual reports (field) Dept. Agric. Straits Setts. and F.M.S., 1930-1932).

Beetle pest *Craniotectus corbetii* greatly reduced derris cultivation in Johore.

Panshin, A. J., 1937.—Wood anatomy of certain South American rotenone-yielding plants. *Amer. J. Bot.* 24 (9): 587-591.

Includes anatomy of *Derris amazonica.*

Pflältzer, A., 1931.—Een en ander over akar toeba (*Derris elliptica*). (Notes on . . .) *Bergcult.* 5: 623-625.

A preliminary compilation, based on Malayan publications and on insecticidal literature.

(Philippines).—(*Annual*) *Report of the Director of Plant Industry* 1934 +

*— *Philippines Sugar Association Research Bureau Annual Report* (? years).

(Puerto Rico; Mayaguez).—*Report of the Puerto Rico Experiment Station* 1936 +

(Puerto Rico; Rio Piedras).—*Annual Report of the Agricultural Experiment Station* 1934/35.

Roark, R. C., 1929.—*A bibliography of Derris* (Deguelia) *species used as insecticides* (1747-1929). Insecticide Div. U.S. Bur. Chem. Soils, Washington.

— 1930.—The American market for Tuba root (*Derris elliptica*). *Malay. Agric. J.* 18: 455-457.

Advocates rotenone rather than ether extract as basis of selling price; United States method of rotenone extraction given. Rotenone content ranges "up to 5.5 per cent in commercial shipments".

— 1932.—A digest of the literature of *Derris* (*Deguelia*) species used as insecticides, 1747-1931. *U.S. Dept. Agric. Misc. Pub.* 120. Pp. 86.

*— 1938.—The early history of derris as an insecticide. *Pests* 6 (12): 8-10. (Cf. *Exper. Sta. Rec.* 81: 244.)

*— (n.d.).—The history of the use of derris as an insecticide. Part II—the period 1919-1928. *Bur. Ent., U.S. Dept. Agric., Mon. E.* 468 (cit. Holman 1940).

*— 1939.—List of common names used for species of *Derris* in connexion with insecticidal properties. *U.S. Dept. Agric. Bur. Ent. Plant Quar.* 1939, E 477. (Cf. *Exper. Sta. Rec.* 81: 805.)

— 1939.—Insect pests of derris. *J. Econ. Ent.* 32: 305-309.

Mainly *D. elliptica.*

— 1941.—Present status of rotenone and rotenoids. *J. Econ. Ent.* 34 (5): 684-692.

Includes references to cultivation and pests of derris.

Russell, W., 1937.—Note sur la structure de la racine de *Derris elliptica. Rev. Bot. Appl. Agric. Trop.* 17: 539-540.

Apparently derived from Maheu (1925) and Chevalier, J. and M. (1937).

*Sakai, K., 1934.—A scolytid attacking the root of derris. *Kontyu* 7 (5/6): 272-273. (*Rev. Appl. Ent.* (A) 22: 240.)

*Santos, P. R., 1941.—Leaf spot of derris. *Philipp. Agric.* 29 (8): 641-659.

Phyllosticta derridis does not kill the plants but reduces synthetizing efficiency (cf. *Exper. Sta. Rec.* 85: 370, 1941).

Scarone, F., 1937.—Les plantes á rotenone. *Agron. Colon.* 26: 79-86, 107-118.

Possibilities of derris in Indochina.

*(Schmitt, N.), 1930.—*Derris elliptica* Benth., ein vegetabilischer ungiftiger Insecticidlieferant. *Angew. Bot.* 12: 453-463.

— 1932.—Kultuur und Absatz der *Derris elliptica* Benth. *Tropenpflz.* 35 (9): 375-380. Also long summary (French) in *Rev. Bot. Appl. Agric. Trop.* 13: 67-70.

Methods of growing and sources of cuttings and roots.

*Schuitemaker, J. P., 1935.—Voorkomen en eigenschappen van eenige toeba soorten in West-Borneo. *Ind. Mercuur.* 58 (12): 165-168.

(Seychelles), 1938.—Annual report of the Department of Agriculture for the year 1936.

Megachile seychellensis, a leaf-cutter bee, causing considerable minor damage. Reference omitted from Roark's compilation (1939).

Sievers, A. F., 1940.—The production and marketing of derris root. U.S. Dept. Agric. Bur. Plant Indus., Div. Drug and Related Plants. Pp. 23 incl. bibliog. 150, largely of unpubl. items.

— 1943.—El barbasco (derris). *Rev. Instit. Def. Cafe Costa Rica* 13: 621-632.

A useful summary but containing no references to work on derris in Puerto Rico, the Philippines or Tanganyika. No bibliography.

Sievers, A. F., and Higbee, E. C., 1943.—Plants for insecticides and rodenticides. *Foreign Agric. Rep.* 8. (Pp. 5-8 give a brief summary of derris-growing methods.)

Sl—, 1939.—Derris. *Bergcult.* 13: 444-446. Based on Georgi (1939a).

Silayan, H. S., 1940 a.—*Commonwealth of the Philippines, Department of Agriculture and Commerce, Bureau of Plant Industry, Manila. Annual Report of the Director of Plant Industry for the year ending 31st December, 1938.* Manila.

— 1940 b.—. . . *Semi-annual Report of the Director of Plant Industry for the period from 1st January to 30th June, 1939.* Manila.

In 1938 report pp. 47-48 + pl. 9, in 1939 Report pp. 59-61 deal with derris selection and experiments on climatic effects, liming, staking, inoculation and methods of planting cuttings.

Simmons, R. D. G. T., 1940.—Invloed van derris, flit en andere insecticiden op menschen en dieren. (Effect of derris, flit and other insecticides on men and animals.) *Bergcult.* 14: 808-810, extracted in *Trop. Agric.* (*Trinidad*) 9: 187 (1941).

Smee, C., 1939.—Gelatine grub (*Niphadolepis alianta* Karsch). *Nyasaland Tea Assoc. Q. J.* 3 (2): 5-7.

Possibly feeds on derris plants.

South, F. W., 1924.—Annual report of the Chief Agricultural Inspector for 1923. *Malay. Agric. J.* 12: 219-237.

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ORIGINS OF SOME EAST AFRICAN FOOD PLANTS

PART IV

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GRAINS—(*Contd.*)

MAIZE, *Zea mays* L. *Mhindi* or *Muhindi*. This is an American plant of very ancient cultivation in the New World. Explorers in America in the sixteenth and seventeenth centuries found it from the Great Lakes of North America to Chili. The evidence points to Central and Southern Mexico as the original home of maize.

Columbus met with it on his first voyage in 1492, and he and his men ate it with relish and made bread from it. Within a short time maize had been carried to, and grown in, nearly every other continent.

Apparently the first maize brought to Europe by the Spaniards came from the West Indies and it was established in Spain. It is known that from the year 1500 maize was sent from America to Seville for cultivation, and from there it was introduced into other parts of Eastern Europe, Turkey and North Africa, and it was recorded in Ethiopia in 1623. The Spaniards also took it to the Philippine Islands.

Some authorities say that maize had reached China by crossing the Pacific before the discovery of America. Two missionaries, Herrada and Marin, in 1575 refer to the sowing of maize among pine-trees in China. Maize also seems to have reached Asia from the west by way of Turkey, South Russia, Arabia or Persia. An indication of this latter origin is given in one of its Indian names *makka* or *makkai jari* or *joar*=Mecca millet, and its cultivation in India did not become general till the beginning of last century. Since the Swahili name is *mhindi or muhindi* = Indian, one wonders if it was not finally established on the East African coast from India and then only at the beginning of the nineteenth century.

In West Africa it was known in Guinea in 1658, it is believed to have reached the Cape about 1650 through the Portuguese, and it was no doubt planted in the Portuguese settlements on the East African coast.

QUINUA, *Chenopodium quinoa* Willd. This plant is a native of Peru and yields a food grain. It was introduced into Kenya from Kew in 1936 and grown at Kapenguria in the Suk Reserve. There is every possibility of its becoming a native food crop, but it is not at present popular with the natives.

RICE, *Oryza sativa* L. *Mpunga*. There are about twenty species of *Oryza*, and according to Stapf wild rices are found in five main areas: (1) in North Australia, (2) in India, with extensions to Cambodia and possibly Borneo, (3) in tropical Africa from Ethiopia to Tanganyika and extending to the Niger, (4) in Senegambia, extending to the region of Lake Chad, and (5) in South America.

The wild rices in areas 1–3 and possibly some of area 5 are annuals, the remainder perennials. Domesticated rices, which go under the name *Oryza sativa*, have more than one common stock, most having originated from south-eastern Asia, others from tropical Africa and some possibly in South America. Some authorities consider the plains of eastern China and eastern India the first great rice granaries of the world, but not the places where rice was first cultivated.

It seems that rice cultivation spread from the western parts of India about 400-300 B.C.; the Greek historian, Herodotus, travelling in Babylonia between 464 and 447 B.C. does not mention rice, but states that wheat was eaten in Persia. Another Greek historian, Aristobulus, and Alexander the Great's war correspondent, writing after 285 B.C., mentions rice growing in Babylonia as well as in Bactriana and Lower Syria; Theophrastus had a knowledge of rice. It was grown in all parts of Persia at the beginning of the Christian era; about the same time, before the Egyptians grew it, rice was brought from India, as well as from Syria, to Egypt. With the Arab conquest of Egypt and North Africa rice reached Spain. Rice was certainly cultivated on the East African coast before the arrival of the Portuguese and some indication of its origins can be assumed by the use of numerous Arabic and Indian vernacular names by the natives for the many varieties cultivated here.

RYE, *Secale* spp. *Ngano*. A cultigen* derived from *S. montanum* Guss., a perennial species found on the mountains bordering the Mediterranean in North Africa and Europe and extending as far as Central Asia. The cultivation of rye in East Africa cannot be earlier than the end of the last century or the beginning of this and was probably started by German missionaries.

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* Cultigen, a plant, group or series, only known in cultivation.

SORGHUM, *Sorghum vulgare* Pers. *Mtama*. Great millet, guinea corn, kaffir corn; *S. vulgare* has now been separated into thirty-one species with a host of varieties and forms all of which belong to the Series *Sativa*, Subsect. *Arundinaceae*. Their origin is African as they are centred in Africa, with a few species extending northwards to the Mediterranean, eastwards to Arabia and India, as well as Ceylon and the Mascarene Islands, whilst one is found in China and another in Malaya. They are most abundant in tropical Africa near the Equator and up to 15°N. Their three main centres of distribution are West Africa, the Anglo-Egyptian Sudan and Tanganyika southwards.

The wild sorghums, *S. arundinaceum* (Willd.) Stapf, *S. verticilliflorum* (Steud.) Stapf, *S. aethiopicum* (Hack.) Rupr. ex Stapf and *S. sudanense* (Piper) Stapf, of the Series *Spontanea* in the Subsect. *Arundinaceae* are all found in tropical Africa and are believed to have played some part in the evolution of the cultivated races as the first three are closely related to them and readily cross with them.

The Arabic name for sorghum is *dhurra*, and the Arab philosopher, Avicenna (A.D. 980–1037), in the tenth century mentions *dhurra* as a food grain of the people of Zanzibar. Beer and food races are grown by the natives; many of the former cannot be used as a substitute for the latter.

WHEAT, *Triticum* spp. *Ngano*. Two species, *T. aegilopoides* Bal. and *T. dicoccoides* Korn., and eleven races with innumerable varieties have been recognized in the cultivated wheats. *T. aegilopoides*, a wild species, is found in Greece, South Bulgaria and Serbia, and a race of it has been cultivated from very early times by primitive peoples in Europe and Western Asia. *T. dicoccoides* has been found wild in Palestine and the mountains of Western Persia. It has a race, *T. dicoccum* Schubler, of cultivation so ancient that it has been found in the neolithic Lake dwellings of Switzerland. It was in cultivation in Egypt from the earliest times and is said to have been the chief cereal in ancient Babylon. Wheat grain has been found in a brick of the pyramid of Dashur to which the date of 3359 B.C. has been assigned.

In *T. dicoccoides* the races *T. dicoccum* and *T. pyramidale* Percival are in cultivation in Ethiopia and they are thought to have originally come from Southern Arabia. Since the Italian occupation others have been introduced, but the extent of their spread is not known. The East African coast is climatically unsuitable for wheat and if introduced by early voyagers it would not have survived. The Swahili name *ngano* is said to be derived from the Portuguese word *grao grano* = rye.

In Tanganyika, at Tabora and Karagwe wheat from Southern Arabia was first cultivated as a garden crop by the Arabs, at the former place in 1852. It is cultivated as a food crop by the Wakinga, Wawanji, Wasafwa, Wambwila, Wamalilae, Wasongwe in the highlands of south-western Tanganyika. According to the Wakinga their seed was obtained from missionaries who brought it by way of Nyasaland.

It was introduced to the natives in Uganda by the White Fathers' Mission about 1912 and distributed to the Bakonjo, a tribe of hillmen living on the slopes of the Ruwenzori Mountains.

OIL SEEDS

CASHEW NUT, *Anacardium occidentale* L., *Mbibo, Mkanju* and *Mkorosho* the tree; *Bibo* the apple-like part of the fruit, *Korosho* the nut. This small tree is a native of tropical America, where it is rather widely distributed. Its introduction into East Africa is due to the Portuguese, who seem to have taken a considerable liking for the nut, which they sometimes imported into Lisbon. They were active in distributing the seed, according to Garcia da Orta's *Colloquies* (1563). The earliest possible date that it could have been introduced into East Africa is about 1505, when the first garrison was established at Kilwa. It was recorded by Loureiro in East Africa in the second half of the eighteenth century. The cashew is now naturalized on the East African coast and is particularly common on the island of Mafia and on the eastern side of Pemba.

The Brazilians squeeze out the juice from the apple and drink it fermented, the African also makes a very potent spirit from the apple and one wonders if this use was imparted from the Americas by way of the Portuguese. The word "cashew" is derived from the Brazilian word *caju*, taken from the Tupi language and usually spelt by the Portuguese *cajous*.

COCO-NUT, *Cocos nucifera* L., *Mnazi* the palm, *Nazi* the nut. The original home of the coco-nut is not known, as it is now found fringing the sea-shores of all tropical countries. The outer husk of its fruit is fibrous, very light and full of air, the seed coat very hard and bony, and its distribution, in part, is due to its buoyancy which has assisted in its dispersal by sea. As its nearest allies, *Attalea, Maximiliana*, and *Orbignya*, are American, some authorities consider it to be American.

There are three theories which aim at accounting for its distribution in the tropics: (1) that it came from the stock which gave the American members of the genus, originated in the northern end of the Andes, and was taken into the Pacific by pre-historic voyagers; (2) that from a place of origin on the coast of Central America the equatorial sea currents, which cross the Pacific westwards, carried it to the Pacific islands; (3) that, having originated in southern Asia, or in Malaysia, or in the Pacific, it reached America from the Pacific islands, perhaps by accident.

One authority says, "The original home of this now ubiquitous palm appears certainly to be in Costa Rica and Panama." It was observed there by Oviedo in 1515, and by the Spanish author Acosta (1539?-1600), in San Juan de Porto Rico, in 1570-1587. The English pirate and navigator Dampier (1652-1715) in 1686 records the coco-nut as growing from Ecuador to Mexico. The Spanish and French took it to the West Indies, and distributed it along the southern shores of the Caribbean. It is known that the Portuguese took it to Bahia and to other places in eastern Brazil, as Piso (*Historia naturalis Brasiliae*, 1658) saw it there in 1636 and spoke of it as an exotic. They also took it to West Africa in 1498, but found it already in East Africa.

Peter Martyn, an early voyager, in an account of a voyage in 1520 mentions the coco-nut as occurring in the Moluccas. There is a reference to a palm which is thought to be the coco-nut in an Egyptian inscription of 1650 B.C., the earliest known. Moresby and Dampier found the palm in abundance on the coast of New Guinea and the islands of the Torres Straits, whilst Marco Polo records it in Sumatra, Nicobar, Andamans, Madras and Malabar in 1280. In the temple of Angkor Wat in Cambodia, built in the eleventh and twelfth centuries, are carvings clearly representing the coco-nut, together with that of a *Borassus*.

The arrival of the coco-nut in East Africa may have been due to sea-drift, like that of *Casuarina equisetifolia* L. and *Barringtonia speciosa* Blume, two East Indian strand plants, or to prehistoric voyagers, as the shell is a container of both food and drink.

GROUNDNUT, *Arachis hypogaea* L., *Mnjugu*, *M. nyasa* or *Mkaranga*. This is a cultigen* which was widely grown in South America at the time of Columbus, and thereafter spread very rapidly to the Old World tropics. It was at one time thought to be African, but as ten other species have been described from Brazil and Paraguay, its supposed African origin has had to be abandoned.

Oviedo records that, between 1513 and 1525, it was found in great abundance in gardens in the West Indies. A protestant pastor, Jean de Léry, sent with French colonists to Brazil by Admiral Coligny, described the plant in Rio de Janeiro in 1555. It was again recorded from Brazil in 1570 by the Portuguese Gabriel Soares de Souza.

It is believed to have been well established in Senegambia by about 1564, as Alvares da Almada saw it there at that date, but doubt has been cast on so early an introduction from America, and it may have been *Voandzeia* that Almada saw. The botanist Clusius (1526-1609) indicates that groundnuts were part of the provisions of slave ships when crossing the Atlantic in 1601. This would indicate that supplies were readily available in West Africa at that date. It was observed in Sofala by Loureiro in 1782, and its establishment on the East African coast is no doubt due to the Portuguese. Groundnuts made their appearance as a commercial product in Europe about 1840.

OIL PALM, *Elaeis guineensis* Jacq., *Mchikichi*. The cultivated form of this West African palm was established, probably from the Congo, by the Arabs at Ujiji on the eastern side of Lake Tanganyika, a settlement made by them in 1845, where Stanley met Livingstone in 1871. Other plantings made by the Arabs were in scattered places such as Bukoba and at the north-east of Kihurio, between the Southern Pares and Western Usambaras on the old Pangani-Kilimanjaro caravan route. It was not introduced by the Portuguese from the west to the east coast, but plantations were established by the Germans at Amani, Derema and Magrotto in the East Usambaras at the beginning of this century.

The cultivated form, with its stout stems and long and heavy leaves, must not be confused with the wild form with its slender stem, smaller and more graceful leaves, and fruits which are hard-shelled and yield little oil. This wild form has a very scattered distribution in East Africa, and is seen at its best in swamp forest in Zanzibar and Pemba.

OYSTER NUT, *Telfairia pedata* Hook., *Mkweme* the plant, *Kweme* the seed. This is a native of East Africa, and is found sporadically from Mozambique to Uganda, as well as in Zanzibar and Pemba. It is an important oil seed to some tribes. Attempts to grow it on a plantation scale have not been successful. The native method of growing it is to have a few plants growing over widely scattered indigenous trees around their gardens and not in close stand, where the plants would be subject to attack by diseases and insect pests.

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* Cultigen, a plant, group or series, only known in cultivation.

SESAME, SIMSIM, *Sesamum orientale* L., *Ufuta*. The original home of this plant is believed to Africa. The genus contains some eighteen species, all of which are African; of these about eight are recorded in Angola, six in Damaraland, five in Senegambia, four in Uganda and Tanganyika, *S. orientale* being the most widely distributed. It was cultivated before 1300 B.C. in Egypt, and is frequently mentioned by the Greeks and Latins. It had already come into cultivation as a crop of the Chaldeans, and increased in importance eastwards to India; both India and China received it by way of Persia, and it is thought to have been taken to India before it found its way to Egypt and Europe. Chinese writers consider it of recent post-Christian introduction into Asia. The Portuguese took it from the Guinea coast and established it in Brazil.

There is a great diversity of forms, from white seeded through red to black seeded, the majority from tropical Africa having light-coloured seeds, from Ethiopia and Eritrea brown seeds. Sesame oil is not only of importance in native cooking and food, it is much used as an unguent.

SPICES AND CONDIMENTS, ETC.

BETEL-NUT, *Areca catechu* L., *Mpopoo*. This palm is not known in a wild state, but is cultivated throughout the hot damp regions of Asia and the Malay Islands. It is a masticatory of great antiquity with some Asiatic races, and is chewed with the leaves of betle pepper. The earliest reference by a European to the habit of chewing betel-nut seems to be that of Marco Polo, A.D. 1298, who states, "All the people have the habit of keeping in the mouth a certain leaf called tembul." Vasco da Gama in 1498 was another who commented on this custom. Its cultivation in East Africa is restricted to hot moist places on the coast, and it is in commercial production in Zanzibar and at the mouth of the Pangani River in Tanganyika; in the latter place it was observed by the explorer Lieut. Höhnnel on Count Teleki's expedition to Lake Rudolf in 1887. The betel-nut may have been introduced at the time of the Persian colonization of East Africa between A.D. 1000 and 1400 or earlier by Chinese, Arab and Indian traders, or by the Hovas by way of Madagascar.

BETLE PEPPER, *Piper betle* L., *Mtambuu*. This plant is believed to be a native of central and eastern Malaysia, but in comparatively early times it became cultivated through tropical Asia and Malaysia. Its cultivation and use along with the betel-nut as a masticatory in India is ancient, but west of India it is comparatively modern. Garcia da Orta, writing in 1563, and Linschoten in 1598, say it was grown near all the tropical moist coasts known to them, but not in China or Mozambique. Its use as a masticatory was observed by Ibn Batuta in 1330 in Mogadishu, and by the Portuguese about the beginning of the sixteenth century. It is believed to have been introduced into East Africa at an early date by Indian traders who were well established on the coast before the advent of the Portuguese. It is cultivated in Zanzibar, but is by no means common on the mainland.

CINNAMON, *Cinnamomum zeylanicum* Breyn. *Mdalasini*. This tree is a native of Ceylon, but as other species of *Cinnamomum* were also employed as spice barks it is not possible to give any definite information about it from the classical writers. In A.D. 1500 Ceylon used to send it largely to Calicut for sale to merchants going overseas, and it was about that time that the Portuguese seized Ceylon on discovering that it was that island and not India that supplied the most fragrant bark. The Portuguese established a monopoly and were followed by the Dutch and British; the latter, having gained control of Ceylon, kept up the monopoly for a time, then tried by taxing exports to prevent flooding of the market.

The tree, which is now wild on the islands of Zanzibar and Pemba, may have been introduced to Zanzibar at the same time as the clove, if not earlier. It had been established in a few places favourable to it on the East African mainland by the beginning of this century and is now becoming wild. It is not exploited as a crop in East Africa, but is used where available by the African for flavouring food and tea, also medicinally. For reasons not yet discovered, Ceylon produces better cinnamon than any of the countries to which the tree has been introduced and established.

CLOVE, *Eugenia aromatica* (L.) Baill., *Mkarafuu* the tree, *Karafuu* the clove. This tree is a native of the islands of Ternate, Tidore, Motir, Makyan and Bachan in the Moluccas. Cloves were known in China in the third century before Christ, and soon after the beginning of the Christian era they were traded at Alexandria and a knowledge of them was passed to Rome. By the fourth century A.D. they were quite well known in the Mediterranean and in the eighth throughout Europe, but their country of origin was unknown. Not until about 1428-1448 was it found out that they came from Banda, when the Venetian explorer and writer, Nicolo Conti (*c.* 1419-1444) announced it. This was confirmed by Pigafetta, a volunteer in Magellan's voyage round the globe, in 1521, and again in 1563 by Garcia da Orta.

There are frequent references to cloves along with pepper, ginger and sugar, by the Portuguese in their early accounts of their voyages up and down the East African coast, but the tree did not grow here, and they were the first to attempt to establish a monopoly in the crop in the Moluccas, in which they failed. They were followed by the Dutch, British and the French.

There is a tradition that a French governor of Mauritius and Bourbon contrived to get the tree in 1770, and at the end of that century an Arab, Harameli bin Saleh, accompanied a French officer from Zanzibar to Bourbon and obtained permission to take back a small quantity of clove seeds and plants with him. On the other hand, Pearce says the introduction of the clove tree into Zanzibar was from Mauritius, about the year 1829, at the instance of His Highness Seyyid Said, who caused it to be cultivated on an extended and systematic scale in Zanzibar and subsequently in Pemba. Pearce further states that this account is confirmed to some extent by official documents at Zanzibar.

While cloves have for many years been the most valuable export of the islands of Zanzibar and Pemba, the tree has never been established on any scale on the mainland.

CORIANDER, *Coriandrum sativum* L., *Mgiligilani*. This spice is a native of the Mediterranean and the Caucasus and is the oldest known spice, being mentioned in early Egyptian papyri and its seeds have been found in Egyptian tombs of 960-800 B.C., which suggests that it held an important place in Egyptian gardens. It was in Persia before 500 B.C., and from there it had reached China before A.D. 1000. Its seeds were in the shops of Pompeii in the first century, but although grown in Italy, Pliny states the best came from Egypt. It is extensively cultivated in India, and is imported by the Indians into East Africa. It is cultivated in places in East Africa, especially by the Watussi and Wahuma.

FENUGREEK, *Trigonella foenum-graecum* L., *Uwatu*. This is native of the Mediterranean and the Near East, but its cultivation extends to western India and to China. It is cultivated to a limited extent in East Africa for its seeds, which are used by Indians as a condiment in curries, and the leaves and young fruits are also used as a vegetable. It is believed to be a comparatively recent introduction into East Africa by Indians.

GINGER, *Zingiber officinalis* Rosc., *Mtangawizi* the plant, *Tangawizi* the root. This plant is a cultigen* that has been in India and China from the earliest times. Its dried rhizomes were known to the Greeks and Romans not later than the first century A.D., for both Dioscorides (the Greek writer) and Pliny mention it without knowing its origin, and it was not till the third century that Europe found out that it came from India. It was well-known in England before the Norman conquest and was nearly as common in trade as pepper.

About the twelfth century the Arab historian and geographer, Ibn Sayd Abulfeda (1273-1331), reports that a ginger is said to grow at Malindi, and in 1330 Ibn Batuta states that when in Mogadishu he ate fresh ginger. In spite of the Portuguese references to ginger being part of the cargo of Arab ships on the East African coast at the beginning of the sixteenth century, the plant has not been established in modern times on a commercial scale in East Africa, though it is cultivated in places to a very limited extent by the African. Ginger was spread by the Portuguese from East to West Africa in the sixteenth century.

NUTMEG AND MACE, *Myristica fragrans* Hout., *Kungumanga* the seed, *Basibasi* mace. This is a native of the eastern islands of the Moluccas, called the Spice Islands from the presence of this tree and the clove, and also to other eastern islands of the Malay Archipelago, including Banda, famous for its nutmegs.

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* Cultigen, a plant, group or series, only known in cultivation.

Nutmegs do not appear to have been known to the Greeks and Romans, but they were carried by Arab traders from the East Indies in the early days, and the first known reference to them is by a Greek physician, Aetius, resident at the court of Constantinople about A.D. 540. An Arab historian, Masudi (d. *c.* 956), visited India in A.D. 916-920, and pointed out that the nutmeg, like the clove, was obtained from the eastern islands of the Malay Archipelago, but it was not till the thirteenth century when the Arab writer, Kaswini, identified the Moluccas as the home of the nutmeg.

The first record of nutmegs in Europe is in a poem about 1195 by Petrus D'Ebulo, who describes how the streets were fumigated with nutmegs and other aromatics on the entry of the Emperor Henry VI into Rome.

The Portuguese finally located the home of the plant in Banda in 1512, and held a monopoly in these spices until they were driven out by the Dutch, who tried to restrict the trees to Banda and Amboyna. They accumulated so many nutmegs in Holland, supposed to be sixteen years' crops, that in 1760 a vast quantity of both nutmegs and cloves were burnt at Amsterdam to keep up prices.

The French governor of Mauritius and Réunion, Poivre (*c.* 1768), obtained seeds and plants and established the nutmeg in these islands, and from these they were established in the Seychelles and Cayenne. At the beginning of the nineteenth century an Arab of Mauritius or Réunion took some plants, with some cloves, and established them in the gardens of Arabs in Zanzibar. A few trees are to be found on the East African mainland at places such as Pangani, Dar es Salaam and Sigi Segoma, in Tanganyika, but nowhere along the East African coast is the crop of commercial importance.

PEPPER, *Piper nigrum* L., *Pilipili manga*. This climbing shrub is a native of the Malabar coast of India, from where it has been distributed by cultivation to other parts of the tropics. Pepper is one of the earliest known spices, and at one time was the most important item of trade between India and Europe. It is mentioned by Theophrastus in the fourth century B.C. and by Dioscorides and Pliny. The merchant and traveller, Cosmas Indicopleustes (*c.* A.D. 500), about A.D. 540, visiting the Malabar coast, describes the plant; Marco Polo mentions pepper as being produced in Java in 1280, and Nicolo Conti saw it in Sumatra in the fifteenth century. The early Portuguese accounts refer to pepper in Arab ships on the East African coast. In England there are many early references to pepper, the first in the late tenth century, when a pepper tax was imposed, and later peppercorn rents, in which they were paid in kind, usually a pound. No doubt various attempts have been made by the Arabs to establish this plant on the East African coast, but they do not appear to have been successful. At the commencement of this century two plantations had been established in Tanganyika in the Usambara foothills, but the plants seldom fruit freely.

At one time white pepper was thought to be derived from a different plant, but it is only the seed of the black pepper from which the fruit skin has been removed.

RED OR CAYENNE PEPPER, *Capsicum annuum* L., and *C. frutescens* L., *Mpilipili hoho* the plant, *Pilipili hoho* the fruits. These are natives of Central and South America, where they had been cultivated long before the discovery of the New World by Columbus. There are many races and forms of both species. *C. annuum* is a quick-growing annual and *C. frutescens* a perennial that is now found wild in waste places with a fairly high rainfall in East Africa, especially near native habitations. Peter Martyr in 1493 records the bringing of the seed to Spain by Columbus, and Chanca, a physician to the fleet of Columbus on his second voyage, wrote of it in 1494. It was described by Fernandez in his *Historia de las Indias* in 1514.

The Portuguese, together with the Spaniards, in their search for pepper were quick to seize this new and much more pungent pepper from America, and its spread to other parts of the tropics was very rapid. It was cultivated by the English herbalist and surgeon, Gerarde (1545-1612), in 1597 in England, where at that time it was sold in Billingsgate shops as "ginnie pepper". Before 1542 it was brought from India as Calicut pepper to Germany, and described and figured by the German physician and botanist, Fuchs (1501-1566). According to Clusius it was brought by the Portuguese from Pernambuco and cultivated abundantly in Castile and Moravia in 1585, where Garcia da Orta writes of it being in cultivation in 1593.

It was no doubt an early introduction into Goa by the Portuguese, who began to export it in competition with the true pepper, and it was probably established in their trading stations at the same time, or soon after, on the East African coast.

(To be continued)

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